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IDENTIFIERS	DACUM Process

ABSTRACT

This package consists of course syllabi, an instructor's handbook, and a student laboratory manual for a 2-year vocational training program to prepare students for entry-level employment as manufacturing technicians. The program was developed through a modification of the DACUM (Developing a Curriculum) technique. The course syllabi volume begins with the MASTER (Machine Tool Advanced Skills Technology Educational Resources) Program Consortium competency profile with 12 duties (and supporting technical workplace competencies): practice safety; apply mathematical concepts; interpret engineering drawings and control documents; recognize different manufacturing materials and processes; measure/inspect; perform conventional machining; perform advanced machining; program using CAM (computer-aided manufacturing) system; use computers; participate in total quality and SPC (statistical process control) activities; maintain electrical devices; and maintain hydraulic/pneumatic devices. The first volume contains the justification, documentation, and course syllabi for the courses. Each syllabus contains the following: course description; prerequisites; course objectives; required course materials; methods of instruction; lecture outline; lab outline; Secretary's Commission on Achieving Necessary Skills competencies taught; and appropriate reference materials. The two-volume instructor's handbook consists of technical training modules that include some or all of the following: time required; duty; task; objective(s); instructional materials list; references; student preparation; introduction; presentation outline; practical application; evaluation; summary; and attachments, including handouts, laboratory worksheets, and self-assessment

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with answer key. The handbook is arranged by duty grouping, with technical modules developed for each task box on the competency profile. The student laboratory manual contains a DACUM chart and learning modules for duties A-L. Each module in the student manual includes some or all of the following: objectives, outline, laboratory exercises, laboratory aids, and handouts. (MN)

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ED 422 491

Manufacturing Technology Series
Educational Resources for the Machine Tool Industry
Course Syllabi
Instructor's Handbook
Student Laboratory Manual

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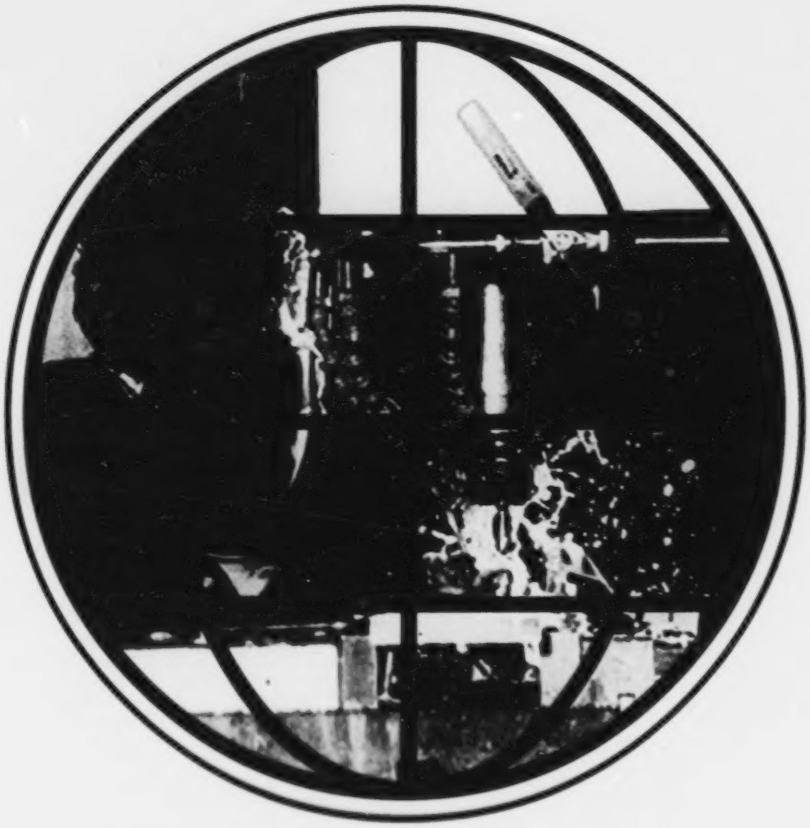
MACHINE TOOL ADVANCED SKILLS TECHNOLOGY EDUCATIONAL RESOURCES

MASTER

a consortium of educators and industry

EDUCATIONAL RESOURCES
FOR THE
MACHINE TOOL INDUSTRY



Manufacturing Technology Series
COURSE SYLLABI

Supported by the National Science Foundation's Advanced Technological Education Program

MACHINE TOOL ADVANCED SKILLS TECHNOLOGY EDUCATIONAL RESOURCES

MASTER

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EDUCATIONAL RESOURCES
FOR THE
MACHINE TOOL INDUSTRY

Manufacturing Technology Series
COURSE SYLLABI

Supported by the National Science Foundation's Advanced Technological Education Program

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National Science Foundation
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National Science Foundation - Division of Undergraduate Education
MASTER Consortia of Employers and Educators

MASTER has built upon the foundation which was laid by the Machine Tool Advanced Skills Technology (MAST) Program. The MAST Program was supported by the U.S. Department of Education - Office of Vocational and Adult Education. Without this prior support MASTER could not have reached the level of quality and quantity that is contained in these project deliverables.

MASTER DEVELOPMENT CENTERS

Augusta Technical Institute - Central Florida Community College - Itawamba Community College - Moraine Valley Community College - San Diego City College (CACT) - Springfield Technical Community College - Texas State Technical College

INDUSTRIES

AB Lasers - AIRCAP/MTD - ALCOA - American Saw - AMOCO Performance Products - Automatic Switch Company - Bell Helicopter - Bowen Tool - Brunner - Chrysler Corp. - Chrysler Technologies - Conveyor Plus - Darr Caterpillar - Davis Technologies - Delta International - Devon - D. J. Plastics - Eaton Leonard - EBTEC - Electro-Motive - Emergency One - Eureka - Foster Mold - GeoDiamond/Smith International - Greenfield Industries - Hunter Douglas - Industrial Laser - ITT Engineered Valve - Kaiser Aluminum - Krueger International. - Laser Fare - Laser Services - Lockheed Martin - McDonnell Douglas - Mercury Tool - NASSCO - NutraSweet - Rapistan DEMAG - Reed Tool - ROHR, International - Searle - Solar Turbine - Southwest Fabricators - Smith & Wesson - Standard Refrigeration - Super Sagless - Taylor Guitars - Tecumseh - Teledyne Ryan - Thermal Ceramics - Thomas Lighting - FMC, United Defense - United Technologies Hamilton Standard

COLLEGE AFFILIATES

Aiken Technical College - Bevil Center for Advanced Manufacturing Technology - Chicago Manufacturing Technology Extension Center - Great Lakes Manufacturing Technology Center - Indiana Vocational Technical College - Milwaukee Area Technical College - Okaloosa-Walton Community College - Piedmont Technical College - Pueblo Community College - Salt Lake Community College - Spokane Community College - Texas State Technical Colleges at Harlington, Marshall, Sweetwater

FEDERAL LABS

Jet Propulsion Lab - Lawrence Livermore National Laboratory - L.B.J. Space Center (NASA) - Los Alamos Laboratory - Oak Ridge National Laboratory - Sandia National Laboratory - Several National Institute of Standards and Technology Centers (NIST) - Tank Automotive Research and Development Center (TARDEC) - Wright Laboratories

SECONDARY SCHOOLS

Aiken Career Center - Chicopee Comprehensive High School - Community High School (Moraine, IL) - Connally ISD - Consolidated High School - Evans High - Greenwood Vocational School - Hoover Sr. High - Killeen ISD - LaVega ISD - Lincoln Sr. High - Marlin ISD - Midway ISD - Moraine Area Career Center - Morse Sr. High - Point Lamar Sr. High -

Pontotoc Ridge Area Vocational Center - Putnam Vocational High School - San Diego Sr. High - Tupelo-Lee Vocational Center - Waco ISD - Westfield Vocational High School

ASSOCIATIONS

American Vocational Association (AVA) - Center for Occupational Research and Development (CORD) - CIM in Higher Education (CIMHE) - Heart of Texas Tech-Prep - Midwest (Michigan) Manufacturing Technology Center (MMTC) - National Coalition For Advanced Manufacturing (NACFAM) - National Coalition of Advanced Technology Centers (NCATC) - National Skills Standards Pilot Programs - National Tooling and Machining Association (NTMA) - New York Manufacturing Extension Partnership (NYMEP) - Precision Metalforming Association (PMA) - Society of Manufacturing Engineers (SME) - Southeast Manufacturing Technology Center (SMTC)

MASTER PROJECT EVALUATORS

Dr. James Hales, East Tennessee State University and William Ruxton, formerly with the National Tooling and Machine Association (NTMA)

NATIONAL ADVISORY COUNCIL MEMBERS

The National Advisory Council has provided input and guidance into the project since the beginning. Without their contributions, MASTER could not have been nearly as successful as it has been. Much appreciation and thanks go to each of the members of this committee from the project team.

Dr. Hugh Rogers-Dean of Technology-Central Florida Community College
Dr. Don Clark-Professor Emeritus-Texas A&M University
Dr. Don Edwards-Department of Management-Baylor University
Dr. Jon Botsford-Vice President for Technology-Pueblo Community College
Mr. Robert Swanson-Administrator of Human Resources-Bell Helicopter, TEXTRON
Mr. Jack Peck-Vice President of Manufacturing-Mercury Tool & Die
Mr. Don Hancock-Superintendent-Connally ISD

SPECIAL RECOGNITION

Dr. Hugh Rogers recognized the need for this project, developed the baseline concepts and methodology, and pulled together industrial and academic partners from across the nation into a solid consortium. Special thanks and singular congratulations go to Dr. Rogers for his extraordinary efforts in this endeavor.

Dr. Don Pierson served as the Principal Investigator for the first two years of MASTER. His input and guidance of the project during the formative years was of tremendous value to the project team. Special thanks and best wishes go to Dr. Pierson during his retirement and all his worldly travels.

All findings and deliverables resulting from MASTER are primarily based upon information provided by the above companies, schools and labs. We sincerely thank key personnel within these organizations for their commitment and dedication to this project. Including the national survey, more than 2,800 other companies and organizations participated in this project. We commend their efforts in our combined attempt to reach some common ground in precision manufacturing skills standards and curriculum development.

MASTER DEVELOPMENT CENTER
Texas State Technical College

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Manufacturing in Texas
Economic trends have led Texas officials to recognize the need to better prepare workers for a changing labor market. The downturn in the oil, natural gas, ranching and farming industries during the last decade diminished the supply of high-paying, low-skill jobs. Growth in Texas is occurring in the low paying, low skills service industry and in the high skills, high paying precision manufacturing industry. In Texas, projected increases by the year 2000 include 4,050 jobs for machine mechanics (24% growth rate); 4,700 jobs for machinists (18% growth rate); 3,850 numeric control operators (20% growth rate); and 107,150 general maintenance repair technicians (23% growth rate). The National Center for Manufacturing Sciences (NCMS) identified that of the top twenty manufacturing states, Texas experienced the largest increase in manufacturing employment. Manufacturing will add over 70,000 additional jobs in Texas by the year 2000 with increases in both durable and non-durable goods.

Texas State Technical College (TSTC)
Texas State Technical College System (TSTC) is authorized to serve the State of Texas through excellence in instruction, public service, research, and economic development. The system's efforts to improve the competitiveness of Texas business and industry include centers of excellence in technical program clusters on the system's campuses and support of educational research commercialization initiatives. Through close collaboration with business, industry, governmental agencies, and communities, including public and private secondary and postsecondary educational institutions, the system provides an articulated and responsive technical education system.

In developing and offering highly specialized technical programs and related courses, the TSTC system emphasizes the industrial and technological manpower needs of the state. Texas State Technical College is known for its advanced or emerging technical programs not commonly offered by community colleges.

New, high performance manufacturing firms in areas such as plastics, semiconductors and aerospace have driven dynamic change in TSTC's curriculum. Conventional metal fabrication to support oil and heavy manufacturing remains a cornerstone of the Waco campus and is a primary reason TSTC took the lead in developing new curricula for machining and manufacturing engineering technology in the MAST program.

Development Team
- **Principal Investigator**: Wallace Pelton served as the primary administrator and academic coordinator for the MASTER project.
- **Subject Matter/Curriculum Expert**: Steven Betros, Site Coordinator, was responsible for developing skill standards and course/program materials for the conventional machining, mold making and manufacturing engineering technology components of the MASTER project.

Introduction

MASTER research indicates that individuals working as Manufacturing Technicians will preferably have received at least two years of training and education in both academic and technical courses in the areas of manufacturing methods and processes. This training may have been conducted in a vocational institution or college. Our research indicates that a minimum of two years of vocational training will prepare students with entry level skills necessary to begin work as a Manufacturing Technician.

In this two year program, the students progress through a series of courses designed to both educate and train students with knowledge and skills in areas such as manufacturing materials and methods, conventional and CNC machining, computer-aided drafting and design, engineering mechanics and design, computer-aided manufacturing, and robotics. Students receive a wide range of training which enables them to seek jobs in many different manufacturing areas. The Manufacturing Technology Program at Texas State Technical College (TSTC) has been training Manufacturing Technicians for many years and works closely with advisory committee members to make sure that the skills being taught are the skills needed in industry. Students who graduate from this course of study receive Associate of Applied Science degrees from TSTC. The MET Department worked closely with the MASTER staff, made every effort to assist the MASTER staff with research, and currently seek adoption of the recommended MASTER materials for their MET students. The MET Department at TSTC is recognized throughout Texas by large and small manufacturing companies as a premier source for entry-level technicians. Upon graduation, students are able to interpret complex drawings, select the correct materials, and perform all necessary machining processes. The curriculum has been designed to prepare students to enter the workforce as entry–level Manufacturing Technicians. Laboratory work is emphasized with actual industrial equipment in order to prepare students for interesting, rewarding work in a wide variety of industries. The MET department has a unique blend of theoretical knowledge and practical application which directly corresponds to modern uses in manufacturing. Students may choose from three options of study: Computer-Aided Manufacturing, Machining, and Plastics.

After many interviews with practitioners from industry and discussions with educators, managers, supervisors, and others involved with machine-related occupations (specifically manufacturing technology), the MASTER Consortium Partners have agreed to present our definition of a manufacturing technician as follows:

MANUFACTURING TECHNICIAN - recommends and implements solutions for specific manufacturing applications.

This volume contains the justification, documentation, and course syllabi for the courses which we recommend as minimum training for individuals desiring to become manufacturing technicians.

The first and most important task of the MASTER program was the development of a foundation upon which all other works could be built. The MASTER Competency Profile is this foundation.

The MASTER Competency Profile

Development of Competency Profiles at each of the MASTER sites began with visits to representative companies for the purpose of surveying expert workers within the industry and occupational areas under investigation. Each site began the survey process by asking a subject–matter expert in the targeted technical area, generally a member of its faculty, to employ a modified version of the generally accepted DACUM (Developing A Curriculum) method to categorize the major skills needed to work in the selected occupation. As source materials, the college instructors drew on their professional knowledge and experience of current industry requirements and trends. The initial skill standards developed by the subject–matter experts underwent numerous internal reviews and revisions within each site, assuming final form as a series of structured survey and interview questions designed to elicit a simple yes or no response.

To determine an appropriate survey sample, each site compiled a database of its region's small and medium-sized manufacturers and searched for companies likely to employ workers in the targeted occupational area. The resulting cross-industry samples were sorted further to achieve a balance of technological capability and workforce size; the sample companies within each region were then asked to participate in the project. Willing respondents were scheduled for interviews.

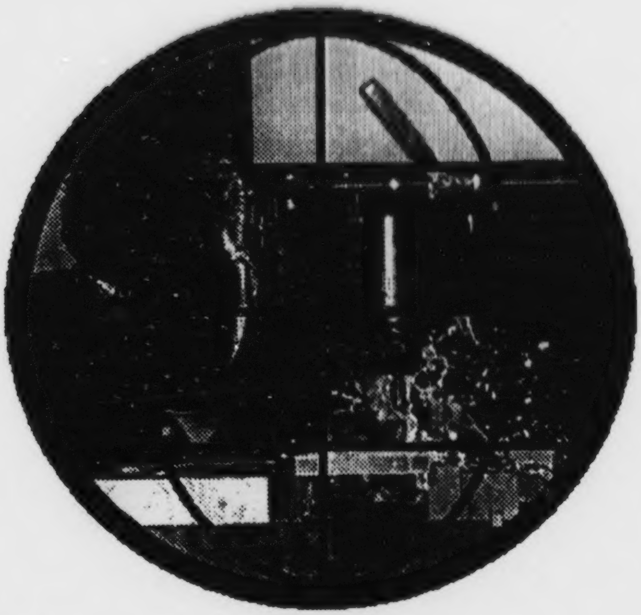
During the company interviews, the MASTER staff asked expert workers to identify the primary duties and tasks performed by a typical worker and to consider the special skills and knowledge, traits and attitudes, and industry trends that would have an impact on worker training, employability, and performance both now and in the future. The interview results were analyzed to create individual profiles identifying the most common duties and skills required of workers at each company. These individual company Competency Profiles served two purposes. First, they showed, in a format that could be easily understood by both industries and educators, a picture of the occupational specialty at a given company at that particular time. Second, these individual company Competency Profiles furnished the company with a document over which they could claim ownership. This, in effect, made them real partners in the work of MASTER.

Data for all companies were then aggregated to develop a composite Competency Profile of industry skill standards within the selected occupational specialty area of Manufacturing Technology, as shown on the following pages.

These same duties and tasks were then included in both the Texas and National Surveys for further validation. As a result of the surveys, additional refinements were made in the Competency Profiles. These changes were incorporated into the individual course syllabi which were used for the pilot program.

The MASTER Competency Profile for Manufacturing Technician has been included on the following pages.

Manufacturing Technician
Competency Profile



Job Analysis conducted and prepared by

MASTER

*M*achine Tool *A*dvanced *S*kills
*T*echnology *E*ducational
*R*esources Program
Consortium

MANUFACTURING TECHNICIAN

Technical Workplace Competencies

Duties	Tasks			
A **Practice Safety**	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment
	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/Control chemical hazards	
B **Apply Mathematical Concepts**	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations
	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems
	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces
	B-13 Use all functions on a scientific calculator	B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications	
C **Interpret Engineering Drawings and Control Documents**	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing
	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning
	C-9 Understand and use quality systems	C-10 Verify standard requirements		

MANUFACTURING TECHNICIAN

Technical Workplace Competencies

Duties	Tasks			
D **Recognize Different Manufacturing Materials and Processes**	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness
	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes		
E **Measure/Inspect**	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables
	E-5 Measure/inspect using surface plate and accessories	E-6 Inspect using stationary equipment		
F **Perform Conventional Machining**	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses
	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines
G **Perform Advanced Machining**	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)
	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network	
H **Program Using CAM System**	H-1 Understand CAD/CAM programs	H-2 Manipulate CAD Functions	H-3 Process simple toolpath data	H-4 Create advanced surface models

MANUFACTURING TECHNICIAN

Technical Workplace Competencies

	Duties	Tasks			
H	**Program Using CAM System (continued)**	H-5 Process complex toolpath functions			
I	**Use Computers**	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages
J	**Participate in Total Quality and SPC Activities**	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts	
K	**Maintain Electrical Devices**	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices	
L	**Maintain Hydraulic/ Pneumatic Devices**	L-1 Troubleshoot, maintain and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems		

Manufacturing Technician
Skills, Traits, and Trends

Skills and Knowledge
Communication Skills
Mathematical Skills
Reading/Writing Skills
Organizational Skills
Basic Knowledge of Fasteners
Conversance with the Technical Language of the Trade
Knowledge of Occupational Opportunities
Knowledge of Employee/Employer Responsibilities
Basic Understanding of Costs: Direct/Indirect
Interpersonal Skills

Traits and Attitudes
Strong Work Ethic
Punctuality
Dependability
Honesty
Neatness
Safety Consciousness
Motivation
Responsibility
Ability to Work as Part of Team
Professionalism
Trustworthiness
Personal Ethics
Patience
Meticulousness
Methodicalness
Willingness to Learn
Mechanical Aptitude

Tool/Equipment Proficiency
Machinist's Tools (e.g., calipers, dial indicators, magnetic tool holders, etc.)
Measuring Tools
Power Tools
Metal Lathe with Attachments
Drill Presses
Vertical Mill with Attachments
Power Saws
Power Drills
Hydraulic/Arbor Press
Heat Treatment Equipment
Hardness Testing Equipment
Grinding Machines with Attachments
Welding Equipment (SMAW, GMAW, FCAW, Plasma)
CNC Machining Center and Turning Center
Gear Producing Machines with Attachments
Alignment/Calibration Tools
Coolant Recovery Equipment
Computer
Ventilation Equipment
Forklift
Personal Safety Equipment
Oxyacetylene Equipment
Tool Storage Equipment
Vises
Weld Test Equipment
Optical Comparator
Coordinate Measurement Machine
Hydraulic/Pneumatic Training Equipment
Electrical Training Equipment
Safety Training Equipment

Current Trends
Statistical Process Control
Composites
Laser Machining
Advanced Computer Applications
Robotics
Fiber Optic Controls
Automated Material Handling Equipment
Computer Integrated Manufacturing
More Stringent Environmental Regulations
ISO 9000 Certification

The MASTER Pilot Program
Curriculum and Course Descriptions

After completing the Competency Profile for each occupational specialty area, each **MASTER** partner reviewed its existing curriculum against the industry-verified skill standards in order to identify a suitable foundation for new pilot training programs. Because each college had to comply with the requirements of its respective college system and appropriate state agency, the resulting pilot curricula for occupational specialty areas tended to vary in format and academic requirements (e.g., some programs were based on the semester system, others on the quarter system). Despite differences in the curricula developed at the partner colleges, each of the pilot programs was designed to achieve the following two goals mandated in the **MASTER** grant proposal:

> ***Pilot Program***: "Conduct a one year pilot program with 25 or more selected applicants at each college or advanced technology center to evaluate laboratory content and effectiveness, as measured by demonstrated competencies and indicators of each program area."
>
> ***Student Assessment***: "Identify global skills competencies of program applicants both at point of entrance and point of exit for entry-level and already-employed technicians."
>
> (*Note*: Not all occupational specialty areas were pilot-tested at all Development Centers; however, all partner colleges conducted one or more pilot programs.)

Included on the following page is the curriculum listing for the pilot program which was used to validate course syllabi for this occupational specialty area. The curriculum also shows the number of hours assigned to each of the courses (lecture, laboratory and credit hours). Also included is a description of each of the courses.

MASTER Curriculum
Manufacturing Technology
(Associate of Applied Science Degree Program)

		LEC	LAB	CR
First Quarter*				
PSYC 1100	College Success Skills	1	0	1
MFG 100	Machine Tool Practices I	3	9	6
DDT 104	Drafting Principles	2	4	3
MATH 1314	College Algebra	4	0	3
ENGL 1301	Composition I	4	0	3
		14	13	16
Second Quarter*				
MFG 200	Machine Tool Practices II	3	9	6
ENGL 134	Interpersonal Communication	4	0	3
MATH 1316	Plane Trigonometry	4	0	3
CNS 2060	Application Software	1	4	3
		12	13	15
Third Quarter*				
MFG 112	Engineering Materials	2	3	3
OSH 216	Safety and Accident Prevention	2	3	3
PHY 114	Fluid Power I	3	3	4
EST 120	Electrical Applications	3	3	4
WLT 105	Survey of Welding Processes & Applications	3	3	4
		13	15	18
Fourth Quarter*				
MFG 205	CNC Machine Programming	3	3	4
MFG 206	Statics	3	3	4
MFG 301	Manufacturing Processes	3	3	4
DDT 128	Introduction to Computer Drafting	1	4	2
PSYC 2301	General Psychology	4	0	3
		14	13	17

*** Each quarter is 12 weeks in length**

		LEC	LAB	CR
FIFTH QUARTER*				
MFG 302	CAD/CAM I	3	3	4
MFG 216	Tool Design I	2	6	4
MFG 312	Strength of Materials	3	3	4
PHYS 1310	Fundamentals of Physics	4	0	3
	Free Elective	2	0	2
		14	12	17
Sixth Quarter*				
MFG 318	CAD/CAM II	3	3	4
MFG 315	Computer Integrated Manufacturing	2	2	3
MFG 324	Quality Assurance & Statistical Process Control	2	3	3
MFG 322	Engineering Technology Project	4	6	6
		11	14	16
	Program Totals	78	80	99

*** Each quarter is 12 weeks in length**

MASTER Course Descriptions

Manufacturing Technology

(Associate of Applied Science Degree Program)

First Quarter

PSYC 1100	**College Success Skills** (1-0-1) This course provides students with the skills and knowledge to be successful in college. Topics include: diversity; self-management/time management; test taking; memory skills; power reading techniques; critical thinking skills; and managing issues that face many college students.
MFG 100	**Machine Tool Practices I** (3-9-6) assigns students specially designed projects that will be machined using the engine lathe, milling machine, drill press, and various saws. The capabilities and safe use of machine tools are stressed.
DDT 104	**Drafting Principles** (2-4-3) consists of basic exercises in lettering, use of the instruments, technical sketching, geometric construction, orthographic projection, auxiliary views, and dimensioning. Working drawings will be made.
MATH 1314	**College Algebra** (4-0-3) includes a study of quadratics; polynomial, rational, logarithmic, and exponential functions; systems of equations, progressions; sequences and series; matrices and determinants. Prerequisite: MATH 104, Intermediate Algebra, or equivalent as determined by math placement test.
ENGL 1301	**Composition I** (4-0-3) includes the process of composing essays, including prewriting techniques, drafting, and revising and editing. Students write several essays of various types, in both in-class and out-of-class settings. Students critically analyze sample student and professional essays. Prerequisite: ENGL 020, Writing Skills II, or equivalent as determined by the English placement test.

Second Quarter

MFG 200	**Machine Tool Practices II** (3-9-6) develops additional machining skills for those students who have the basic skills that were developed in Machine Tool Practices I. Prerequisite: MFG 100, Machine Tool Practices I.
ENGL 134	**Interpersonal Communication** (4-0-3) introduces theories and exercises in verbal and nonverbal communication with focus on interpersonal relationships, the study of internal and external factors that impact communication, communication clarification, and conflict resolution. Various presentations are required. Prerequisite: ENGL 1301, Composition I.

MATH 1316	**Plane Trigonometry** (4-0-3) includes topics in trigonometric functions, right triangles, trigonometric identities, radian measure, graphs of periodic functions, and oblique triangles. Prerequisite: MATH 1314, College Algebra.
CNS 2060	**Application Software** (1-4-3) includes introductory concepts combined with an emphasis on the more predominate computer software including, but not limited to DOS, word processing, electronic spreadsheets, and databases; thus providing non-majors with computer literacy and hands-on experience.

Third Quarter

MFG 112	**Engineering Materials** (2-3-3) is a study of metallic and nonmetallic materials used in design, including properties, characteristics, and methods of conducting common tests and interpreting data.
OSH 216	**Safety and Accident Prevention** (2-3-3) enables the student to recognize hazards and potential hazards which occur in the workplace and to take corrective action. The course may be directed toward a specific technology as required. Federal safety requirements under the OSHA law are emphasized. General supervisor safety training course for all technologies.
PHY 114	**Fluid Power I** (3-3-4) is a study of hydraulic system components, fluid power theory, problem solving, and troubleshooting techniques. Prerequisite: MATH 109, Mathematics for Industrial Technicians, MATH 110, Basic Algebraic Concepts, or equivalent.
EST 120	**Electrical Applications** (3-3-4) is a survey course designed to present basic concepts in DC and AC circuits, fundamental motor design and applications, and basic motor controls.
WLT 105	**Survey of Welding Processes and Applications** (3-3-4) Surveys shielded metal arc, gas tungsten arc, gas metal arc, flux cored arc, and submerged arc welding processes. Metal weldability and weld symbols are considered. Process safety, electrode selection, and process parameters are emphasized. Hard surfacing, using shielded metal arc and oxyacetylene processes and techniques is studied.

Fourth Quarter

MFG 205	**CNC Machine Programming** (3-3-4) introduces programming and operation of a computerized numerical control milling machine using manual machine language. Included are linear and circular interpolation, drilling cycle, and repetitive programming. Prerequisites: MFG 100, Machine Tool Practices I

MFG 206	**Statics** (3-3-4) introduces the field of engineering mechanics covering the calculation of forces and moments acting on machine parts, frames, and structures. The equilibrium of concurrent and coplanar force systems, centroids, and friction are studied. Prerequisite: MATH 1316, Plane Trigonometry, or concurrent enrollment.
MFG 301	**Manufacturing Processes** (3-3-4) Studies the processes and materials for manufacturing, including metal casting, hot and cold forming of steel, powder metallurgy, and plastics. Analyzes newer processes such as electrical discharge machining, chemical machining, and ultra-sonic machining; with an emphasis on the economical manufacturing of products.
DDT 128	**Introduction to Computer Drafting** (1-4-2) introduces the student to Computer-Aided Drafting (CAD). This introduction involves equipment, software, and basic command logic. Graphic images are created using introductory level commands.
PSYC 2301	**General Psychology** (4-0-3) surveys the major topics in psychology, including an introduction to the study of behavior and the factors that determine and affect behavior.

Fifth Quarter

MFG 302	CAD/CAM I (3-3-4) introduces "Process Modeling" utilizing the CNC graphics programming system, "SMARTCAM." Using engineering drawings, students will program various parts for both CNC mills and CNC lathes. Related topics include: job planning, tool selection, construction of a process model, tool path verification, simulation, quality control, CAD/CAM data transfer, and CNC code generation.
MFG 216	**Tool Design I** (2-6-4) requires the students to set up and machine work pieces using the lathe, vertical mill, drill press, and surface grinders. Fasteners, surface finish, and machining techniques typical of tool and die making are used. Prerequisites: MFG 100, Machine Tool Practices I, and DDT 104, Drafting Principles.
MFG 312	**Strength of Materials** (3-3-4) demonstrates the relationships existing between externally applied forces and internally induced stresses, and the resulting deformations of structural members. Prerequisite: MFG 206, Statics.
PHYS 1310	**Fundamentals of Physics** (4-0-3) is an algebra-level, problem-oriented course which presents special topics in classical physics, such as basic mechanics, optics, acoustics, or electricity. Prerequisite: MATH 104, Intermediate Algebra, or above.

Sixth Quarter

MFG 318	CAD/CAM II (3-3-4) continues topics developed in MFG 302, CAD/CAM I, with advanced utilization of "SMARTCAM." Topics include the following: 3–D process modeling, creation and utilization of different work planes, 4th– and 5th–axis programming, creation of tool path for surface primitives, swept surfaces, translated surfaces, sculpted surfaces, ruled surfaces, and coons surfaces. Additional topics include: projecting, intersecting, blending, and trimming one surface to another surface. Students will program both a simple punch and die set and a simple injection mold cavity. Prerequisite: MFG 302, CAD/CAM I.
MFG 315	**Computer Integrated Manufacturing** (2-2-3) introduces the fundamentals of Computer Integrated Manufacturing (CIM), including the key elements and technologies involved. Covers the typical applications which exist in industry today and the major trends affecting the future of manufacturing.
MFG 324	**Quality Assurance and Statistical Process Control** (2-3-3) introduces the concepts of applied quality control systems. Topics covered include quality responsibility, control chart methods, sampling techniques, reliability applications, and computer utilization/programs.
MFG 322	**Engineering Technology Project** (4-6-6) assigns to students, utilizing team concepts, different industrial level projects emphasizing manufacturing applications/research in the areas of CNC, CAD/CAM, CIM or plastics. Prerequisites: MFG 302, CAD/CAM I and MFG 312, Strength of Materials.

The MASTER
Technical Workplace Competencies and Course Crosswalk

After development of appropriate curricula for the pilot programs, each MASTER college began to develop individual course outlines for its assigned specialty area. The skill standards identified in the Competency Profile were cross walked against the technical competencies of the courses in the pilot curriculum. The resulting matrix provided a valuable tool for assessing whether current course content was sufficient or needed to be modified to ensure mastery of entry-level technical competencies. Exit proficiency levels for each of the technical competencies were further validated through industry wide surveys both in Texas and across the nation.

The Technical Workplace Competencies and Course Crosswalk on the following pages presents the match between industry—identified duties and tasks, and the pilot curriculum for Manufacturing Technology. Course titles are shown in columns; duties and tasks, in rows. The Exit Proficiency Level Scale (see Figure 1), an ascending scale with 5 as the highest level of proficiency, includes marked boxes indicating whether the task is covered by the instructor during the course; the numbers 1–5 indicate the degree of attention given to the task and the corresponding proficiency expected on the part of the student upon completion of the course of studies. The crosswalk is intended to serve as an aide to other instructional designers and faculty in community college programs across the nation.

EXIT PROFICIENCY LEVEL SCALE					
Technical Workplace Competency	1	2	3	4	5
	Rarely	Routinely with Supervision	Routinely with Limited Supervision	Routinely Without Supervision	Initiates/ Improves/ Modifies and Supervises Others

Figure 1

Included on the following pages is the Technical Workplace Competencies and Course Crosswalk for the pilot program curriculum. This crosswalk validates the fact that the duties and tasks which were identified by industry as being necessary for entry-level employees have been incorporated into the development of the course syllabi.

Page 1

MANUFACTURING TECHNOLOGY

Technical Workplace Competencies and Course Crosswalk

	Machine Tool Practices I	Drafting Principles	Machine Tool Practices II	Application Software	Engineering Materials	Safety/Accident Prevention	Fluid Power I	Electrical Applications	Survey Welding Applic./Proc.	CNC Machine Programming	Statics	Manufacturing Processes	Intro. to Computer Drafting	CAD/CAM I	Tool Design I	Strength of Materials	CAD/CAM II	Computer Integrated Mfg	QA/Statistical Process Ctrl		EXIT PROFICIENCY LEVEL
A. PRACTICE SAFETY																					
A-1 Follow Safety Manuals and All Safety Regulations/ Requirements	I		R		R	R	R	R	R	R		R	R		R	R		R	M		4
A-2 Use Protective Equipment	I		R		R	R	R	R	R	R		R			R	R		R	M		4
A-3 Follow Safe Operating Procedures for Hand and Machine Tools	I		R		R	R	R		R	R		R			R	R		R	M		4
A-4 Maintain a Clean and Safe Work Environment	I		R		R	R	R	R	R	R		R	R		R	R		R	M		4
A-5 Lift Safely	I		R		R	R			R			R				M					4
A-6 Control Fire Hazards						I	R	R	R												2
A-7 MSDS/Control Chemical Hazards	I		R			R			R			R									2
B. APPLY MATHEMATICAL CONCEPTS																					
B-1 Perform Basic Arithmetic Functions	I		R		R		R			R	R		R	R		R	R		M		4
B-2 Convert Fractions/Decimals	I		R		R		R			R	R			R		R	R		M		4
B-3 Convert Metric/English Measurements	I		R		R		R		R		R		R	R		R	R		M		4
B-4 Perform Basic Algebraic Operations	I		R																R		4
B-5 Use Practical Geometry	I		R						R				R								3
B-6 Understand Basic Trigonometry			I		R					R	R	R		R		R	R		M		4
B-7 Calculate Speeds and Feeds for Machining	I		R		R					R				R			M				4
B-8 Use Coordinate Systems			I							R			R	R			M				4
B-9 Perform Calculations for Sine Bar and Sine Plate			I																		4
B-10 Calculate for Direct, Simple, and Angular Indexing			I																		2
B-11 Perform Calculations Necessary for Turning Tapers			I																		2
B-12 Calculate Depth of Cut for Round Surfaces			I																		2
B-13 Use all Functions on a Scientific Calculator							I				R					R			M		2
B-14 Solve Static Systems for Resultant Force											I					R					3
B-15 Determine Strength of Materials for Various Applications																I					3
C. INTERPRET ENGINEERING DRAWINGS AND CONTROL DOCUMENTS																					
C-1 Identify Basic Layout of Drawings	I	R	R						R	R		R	R	R	R		R		M		4
C-2 Identify Basic Types of Drawings	I	R	R						R	R		R	R	R	R		R		M		4

MFGXWALK.PM6-01/26/98

I=Introduced and Taught R=Repeated and Reinforced M=Mastered

Page 1

MANUFACTURING TECHNOLOGY

Technical Workplace Competencies and Course Crosswalk

	Machine Tool Practices I	Drafting Principles	Machine Tool Practices II	Application Software	Engineering Materials	Safety/Accident Prevention	Fluid Power I	Electrical Applications	Survey Welding Applic./Proc.	CNC Machine Programming	Statics	Manufacturing Processes	Intro. to Computer Drafting	CAD/CAM I	Tool Design I	Strength of Materials	CAD/CAM II	Computer Integrated Mfg	QA/Statistical Process Ctrl		EXIT PROFICIENCY LEVEL
C-3 Review Blueprint Notes and Dimensions	I	R	R		R				R	R		R	R	R	R	R	R		M		4
C-4 List the Purpose of Each Type of Drawing	I		R						R	R				R	R		M				4
C-5 Verify Drawing Elements			I						R	R		R	R	R	R		R		M		4
C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)			I						R	R		R	R	R	R		R		M		3
C-7 Analyze Bill of Materials (BOM)	I		R						R			R		R	R		R	R	M		3
C-8 Describe the Relationship of Engineering Drawings to Planning			I							R		R		R	R		R	R	M		4
C-9 Understand and Use Quality Systems												I			R						3
C-10 Verify Standard Requirements									I	R		R			R				M		3
D. RECOGNIZE DIFFERENT MANUFACTURING MATERIALS AND PROCESSES																					
D-1 Identify Materials With Desired Properties	I		R		R				R			R		R	R	R			M		3
D-2 Identify Materials and Processes to Produce a Part	I		R									R			R		M				3
D-3 Describe the Heat Treating Processes	I				R				R						M						3
D-4 Test Metal Samples for Hardness	I		R		R							R			M						2
D-5 Understand Welding Operations									I						R						3
D-6 Evaluate Plastics, Composites and Other Manufacturing Processes																	I				3
E. MEASURE/INSPECT																					
E-1 Understand Metrology Terms	I		R												R				M		4
E-2 Select Measurement Tools	I		R							R		M									4
E-3 Measure With Hand Held Instruments	I		R						R	R					R				M		3
E-4 Eliminate Measurement Variables	I		R												R				M		4
E-5 Measure/Inspect Using Surface Plate and Accessories	I											R			R				M		3
E-6 Inspect Using Stationary Equipment			I									R									3
F. PERFORM CONVENTIONAL MACHINING																					
F-1 Prepare and Plan for Machining Operations	I		R																		3
F-2 Use Hand Tools	I		R												M						3
F-3 Operate Power Saws	I		R												M						4
F-4 Operate Drill Presses	I		R												M						4

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Technical Workplace Competencies and Course Crosswalk

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F-5 Operate Vertical Milling Machines	I		R												M						4
F-6 Operate Horizontal Milling Machines			I												M						3
F-7 Operate Metal Cutting Lathes	I		R												M						3
F-8 Operate Grinding/Abrasive Machines															R						3
G. PERFORM ADVANCED MACHINING																					
G-1 Prepare and Plan for CNC Machining Operations					I					R				R							3
G-2 Select and Use CNC Tooling Systems					I					R				R							3
G-3 Program CNC Machines					I					R				R							3
G-4 Operate CNC Machining Centers (Mills)														I							3
G-5 Operate CNC Turning Centers (Lathes)														I							3
G-6 Program CNC Machines Using a CAM System														I							2
G-7 Download Programs Via Network														I							2
H. PROGRAM USING CAM SYSTEM																					
H-1 Understand CAD/CAM Programs														I	R		R				4
H-2 Manipulate CAD Functions														I			R				4
H-3 Process Simple Toolpath Data														I			R				3
H-4 Create Advanced Surface Models																	I				2
H-5 Process Complex Toolpath Functions																	I				2
I. USE COMPUTERS																					
I-1 Use Computer Operating Systems				I									R	R				R	M		4
I-2 Understand Computer Terminology				I									R					R	M		4
I-3 Use File Management Systems				I									R					R	M		3
I-4 Install and Use Software Packages																		I			2
J. PARTICIPATE IN TOTAL QUALITY AND SPC ACTIVITIES																					
J-1 Discuss TQM in Manufacturing																			I		3
J-2 Demonstrate Quality Problem Solving Techniques																			I		3

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J-3 Demonstrate Knowledge of SPC Concepts																			I		2
K. MAINTAIN ELECTRICAL DEVICES																					
K-1 Recognize Electrical Components								I													2
K-2 Use Test Equipment								I													2
K-3 Troubleshoot Electrical Devices								I													2
L. MAINTAIN HYDRAULIC/PNEUMATIC DEVICES																					
L-1 Troubleshoot, Maintain, and Repair Hydraulic Systems							I														2
L-2 Troubleshoot, Maintain, and Repair Pneumatic Systems							I														2

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SCANS

The Secretary's Commission on Achieving Necessary Skills (SCANS), U. S. Department of Labor, has identified in its "AMERICA 2000 REPORT" the following five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance:

COMPETENCIES:

Resources:	*Identifies, organizes, plans, and allocates resources*
Interpersonal:	*Works with others*
Information:	*Acquires and uses information*
Systems:	*Understands complex inter-relationships*
Technology:	*Works with a variety of technologies*

FOUNDATION SKILLS:

Basic Skills:	*Reads, writes, performs arithmetic and mathematical operations, listens, and speaks well*
Thinking Skills:	*Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn, and reasons*
Personal Qualities:	*Displays responsibility, self-esteem, sociability, self-management, integrity, and honesty*

Recognizing the value of SCANS proficiencies to job performance as well as the growing mandate in many states to include SCANS activities in course curricula, MASTER asked survey respondents to review the SCANS skill sets in the context of the draft skill standards for each occupational specialty area. MASTER also incorporated an evaluation of SCANS competencies and foundation skills into its assessment of the pilot training curricula. The results were summarized in a crosswalk that allowed the MASTER staff to modify course contents where needed to strengthen the achievement of SCANS competencies.

As soft skills, the SCANS competencies are inherently difficult to quantify. MASTER realizes that some faculty will emphasize the SCANS more or less than others. In time, faculty will learn to make these types of SCANS activities an integral and important part of the teaching process.

MASTER Curriculum
Manufacturing Technology
(Associate of Applied Science Degree Program)

First Quarter*		LEC	LAB	CR
PSYC 1100	College Success Skills	1	0	1
MFG 100	Machine Tool Practices I	3	9	6
DDT 104	Drafting Principles	2	4	3
MATH 1314	College Algebra	4	0	3
ENGL 1301	Composition I	4	0	3
		14	13	16
Second Quarter*				
MFG 200	Machine Tool Practices II	3	9	6
ENGL 134	Interpersonal Communication	4	0	3
MATH 1316	Plane Trigonometry	4	0	3
CNS 2060	Application Software	1	4	3
		12	13	15
Third Quarter*				
MFG 112	Engineering Materials	2	3	3
OSH 216	Safety and Accident Prevention	2	3	3
PHY 114	Fluid Power I	3	3	4
EST 120	Electrical Applications	3	3	4
WLT 105	Survey of Welding Processes & Applications	3	3	4
		13	15	18
Fourth Quarter*				
MFG 205	CNC Machine Programming	3	3	4
MFG 206	Statics	3	3	4
MFG 301	Manufacturing Processes	3	3	4
DDT 128	Introduction to Computer Drafting	1	4	2
PSYC 2301	General Psychology	4	0	3
		14	13	17
FIFTH QUARTER*				
MFG 302	CAD/CAM I	3	3	4
MFG 216	Tool Design I	2	6	4
MFG 312	Strength of Materials	3	3	4
PHYS 1310	Fundamentals of Physics	4	0	3
	Free Elective	2	0	2
		14	12	17
Sixth Quarter*				
MFG 318	CAD/CAM II	3	3	4
MFG 315	Computer Integrated Manufacturing	2	2	3
MFG 324	Quality Assurance & Statistical Process Control	2	3	3
MFG 322	Engineering Technology Project	4	6	6
		11	14	16
	Program Totals	78	80	99

*** Each quarter is 12 weeks in length**

First Quarter

PSYC 1100

MASTER PROGRAM

College Success Skills

COURSE SYLLABUS

Total lecture hours: 12 **Total lab hours: 0** **Credit hours: 1**

COURSE DESCRIPTION:

This course provides students with the skills and knowledge to be successful in college. Topics include: diversity; self-management/time management; tests taking; memory skills; power reading techniques; critical thinking skills; and managing issues that face many college students.

PREREQUISITES: NONE

COURSE OBJECTIVES:

After successful completion of this course, the student will be able to:

1. Understand how he/she is responsible for his/her own experience in college;
2. Describe ways to create a successful and satisfying college experience;
3. Describe methods to:
    a. Improve ability to recall information;
    b. Manage time more effectively;
    c. Read a textbook with improved retention;
    d. Take effective notes;
    e. Prepare for and take tests;
    f. Listen to a lecture for comprehension;
    g. Apply creative and critical thinking skills; and,
4. Examine personal ideas and decisions regarding issues typically faced by college students.

REQUIRED COURSE MATERIALS:

Recommended Textbook:	*Becoming a Master Student*, Ellis, D., Houghton Mifflin Company, Latest Edition
Supplies:	2 pencils (#2) 3-Ring Binder Pen

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture and demonstrations.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete assignments;
2. Apply theory to assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments, including writing assignments and oral presentations;
5. Contribute to class discussions; and,
6. Maintain attendance per current policy; and,
7. Follow all rules and safety regulations.

COURSE OUTLINE

Topics	Contact Hrs.
What Am I Doing Here? Who Are All These People And Where Did They Come From?	3
First Step	
Diversity	
I Need a 27-hour Day! Why Is This String Around My Finger?	3
Time/Self Management	
Memory	
I Have to Read The Whole Book by Next Week? That Professor Talks All the Time And I Can't Keep Up.	3
Power Reading	
Note Taking	
I've Got 4 Tests This Week! Aha!	3
Skills for Taking Tests	
Critical Thinking Skills	—
Total Lecture Hours	12

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies *required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."*

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

- *A. **Resources:** Identifies, organizes, plans, and allocates resources*
  1. Follows a schedule to complete assigned tasks on time
  2. Determines the initial cost of educational expenses and locates appropriate funding sources
  3. Monitors and budgets the flow of money and uses strategies for increasing income and decreasing expenses
  4. Assesses personal strengths and weaknesses and develops appropriate career goals
- *B. Interpersonal: Works with others*
  1. Functions as a member of the team in completing assignments
  2. Provides feedback to peers as requested
  3. Demonstrates good human relation skills and interpersonal interactions
  4. Communicates thoughts, feelings and ideas when appropriate; and responsibly challenges existing procedures, policies or authority
  5. Resolves conflict
  6. Works well with individuals from a variety of ethnic, social or educational backgrounds in completing assigned tasks
- *C. Information: Acquires and uses information*
  1. Engages in problem solving activities
  2. Uses a variety of memory techniques to recall information
  3. Uses critical thinking skills in making decisions
- *D. Systems: Understands complex inter-relationships*
  1. Demonstrates knowledge of organizational structure and follows the chain of command

II. FOUNDATION SKILLS

- **A. Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
  1. ***Reading:** Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
     - a. Reads and studies textbook

   - b. Completes reading assignments
   - c. Interprets reading assignments as demonstrated in classroom dialogue
   - d. Interprets and follows class schedule
- *2. Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   - a. Completes written assignments and quizzes
   - b. Creates an individually designed note-taking system
   - c. Takes class notes
- *3. Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   - a. Completes a time-monitor plan
- *4. Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
   - a. Receives/interprets verbal messages via didactic presentations
   - b. Responds to verbal messages
   - c. Confirms verbal message interpretations both in and out of class
   - d. Makes appropriate behavioral response to verbal messages
- *5. Speaking: Organizes ideas and communicates orally.*
   - a. Participates in classroom discussions
   - b. Organizes ideas and communicates specific questions to the instructor
   - c. Orally affirms understanding of a concept, procedure, or required skill
   - d. Communicates with peers

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

- *1. Creative Thinking: Generates new ideas*
   - a. Develops new ideas for approaching problem solving
   - b. Participates in the brainstorming sessions
   - c. Participates in group problem solving
   - d. Practices the team approach to problem solving
- *2. Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
   - a. Generates a personal and career development plan
   - b. Assesses areas for personal growth and develops a personal growth plan

c. Generates a list of career alternatives and chooses the most appropriate career choices based upon a list of personal attributes
d. Identifies actions required to accomplish personal goals

3. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
a. Learns the steps to problem solving
b. Participates in group and individual problem solving processes
c. Makes daily accommodations to stay on schedule
d. Seeks additional instruction/clarification for assignment completion
e. Balances social and academic life responsibilities
f. Accepts responsibility
g. Demonstrates creative solutions to problems

4. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
a. Participates in activities that encourage accepting responsibility for his/her career success
b. Participates in activities to strengthen belief in self-worth and encourages proactive/responsible choices

5. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
a. Utilizes techniques for adapting learning styles to differences in teaching styles
b. Performs assessment of individual learning style
c. Practices memory techniques
d. Practices reading improvement techniques
e. Utilizes techniques for creative thinking
f. Develops strategies for effective problem solving

6. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
a. Performs self analysis of effective learning styles
b. Utilizes techniques for effective creative thinking
c. Develops strategies for effective problem solving

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
a. Utilizes stress management techniques that facilitate goal attainment
b. Accepts responsibility and develops a proactive attitude, turning individual strengths into academic assets

2. ***Self-Esteem:** Believes in own self-worth and maintains a positive view of self*
    a. Provides positive feedback/encouragement in groups
    b. Provides individual mentoring/counseling to support the educational process
    c. Develops interpersonal skills that will allow him/her to interact with confidence and project a positive self-image
    d. Practices positive peer feedback during daily exchanges
3. ***Sociability:** Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. Participates in discussions of cultural diversity and its benefits
    b. Discusses and demonstrates strategies for effective communication across cultures
    c. Participates in discussions of gender diversity and sexism
    d. Participates in discussions of different learning styles and disabilities
    e. Adopts an attitude of tolerance
4. ***Self-Management:** Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. Assesses self/personal goals and monitors individual progress
    b. Performs goal setting activities
    c. Conducts self-assessment on quizzes
5. ***Integrity/Honesty:** Chooses ethical courses of action*
    a. Meets specific criteria standards to successfully complete the course
    b. Demonstrates honesty and integrity while grading quizzes
    c. Accepts ethical and honest course of action by example
    d. Explores and formulates professional and personal ethical standards

MASTER PROGRAM

Machine Tool Practices I

COURSE SYLLABUS

Total lecture hours: 36 **Total lab hours: 108** **Credit hours: 6**

COURSE DESCRIPTION:

Assigns students specially designed projects that will be machined using the engine lathe, milling machine, drill press, and various saws. The capabilities and safe use of machine tools are stressed.

PREREQUISITES: **NONE**

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Understand the basic aspects of general machine shop work;
2. Practice machine shop safety and logical work sequence;
3. Use and understand shop drawings and precision measuring tools, such as dial calipers, micrometer and vernier calipers; and,
4. Perform basic operations such as turning, threading, milling, drilling, sawing, and shaping metal into finished parts to specific dimensions.

REQUIRED COURSE MATERIALS:

Textbook: *Machine Tool Practices*, Kibbe, Neely, and Meyer, Wiley Pub., Latest Edition

Lab Manual: *Machine Tool Practices I*, Raborn, TSTC Pub., Latest Edition

Student Tool List	**Qty. Req'd.**
Tool Box -	1
Safety Glasses	1 pair
6 inch Ruler	1/8, 1/16, 1/32, and 1/64 inch
Ball Peen Hammer	1
10 inch Adjustable Wrench	1
Center Punch	1
Magic marker, Jumbo, black.	1
Aluminum Oxide Cloth, 9" X 11", 240 Grit	2 sheets
Aluminum Oxide Cloth, 9" X 11", 320 Grit	2 sheets
Tool Steel, 3/8", H.S.S.	2

Flat Mill Bastard File, 10 inch.	1
File Handle	1
Allen Wrench Set, Long English and Metric	1 each
Center Drill #3	1
Scribe	1
Center Gage	1
Screw Driver, 8 inch	1
File Card Brush	1
0-6 inch Dial Calipers	1
Shop Apron (blue denim)	1
Shop Towels (1 roll)	1

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Laboratory: Laboratory will be a hands–on machining process.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments, including writing assignments, and oral presentations;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all shop rules and safety regulations as stated in the laboratory manual.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to the Course	1
Safety	1
Tool Grinding	1
The Machine Shop	1
The Inch Rule	1
The Square	1
The Inch Micrometer	1

Drawings		2
Layout Tools		2
QUIZ I (over above lectures)		1
Semi-precision Layout		1
Hand Tools		1
Hacksaws		1
Files		1
Verniers		1
Vernier Micrometers		1
The Drill Press		1
Drilling Tools		2
QUIZ 2 (over above lectures)		1
Drilling Operations		2
Taps		1
Tapping Procedures		1
Gage Blocks		1
Angular Measuring		1
Precision Layout		2
QUIZ 3 (over above lectures)		1
Oral Presentations*		5
	Total Lecture Hours	**36**

* *(10–15 minute student presentations on assigned machine-related topics. These topics could include future trends or special concerns of the machine tool industry.)*

LAB OUTLINE:

Lab Topics		Contact Hrs.
Shop orientation		2
Use of the cut-off saw		2
Grinding a lathe tool		3
Grinding a mill tool		3
Using the band saw		3
Using the radial drill		3
Using the sensitive drill		3
Bench work		27
Lathe work		27
Mill work		27
Leaving the shop in order		3
Inspecting the finished work		5
	Total Lab Hours	**108**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
A. ***Resources:*** *Identifies, organizes, plans, and allocates resources*
1. Allocates time to complete assigned tasks on schedule
2. Determines and allocates required materials and resources for meeting objectives
3. Evaluates skills, performance, and quality of work and provides feedback

B. ***Interpersonal:*** *Works with others*
1. Participates as a member of the team, contributing to group effort
2. Provides individual assistance/direction to peers as requested
3. Determines and meets expectations
4. Exercises leadership qualities to effectively communicate ideas and make decisions.
5. Negotiates resources in order to accomplish objectives
6. Works well with all members of the class

C. ***Information:*** *Acquires and uses information*
1. Acquires and evaluates information
2. Organizes and maintains information
3. Interprets and communicates information

D. ***Systems:*** *Understands complex inter-relationships*
1. Understands and works well with social, organizational, and technological systems
2. Monitors and corrects performance of system during operation
3. Recommends modifications to system to improve performance

E. ***Technology:*** *Works with a variety of technologies*
1. Chooses relevant procedures, tools, and equipment
2. Applies appropriate procedures and techniques to accomplish tasks

3. Identifies or solves problems to maintain equipment

II. **FOUNDATION SKILLS**

A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks

1. ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
    - a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
    - b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
    - c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
    - d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
    - e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials
2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
    - a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
    - b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
    - c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
    - d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
    - e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. ***Arithmetic/Mathematics:** Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    a. **Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages**
    b. **Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems**
    c. **Demonstrates ability to understand and perform multi-step computations**
    d. **Demonstrates ability to read, interpret, and use standard measuring devices**
    e. **Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively**
    f. **Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance**
    g. **Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines**
4. ***Listening:** Receives, attends to, interprets, and responds to verbal messages and other cues*
    a. **Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery**
    b. **Demonstrates ability to hear, comprehend, and appropriately follow directions**
    c. **Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction**
    d. **Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately**
    e. **Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds**
    f. **Demonstrates ability and maturity to seek and receive additional individualized instruction as needed**
5. ***Speaking:** Organizes ideas and communicates orally*
    a. **Demonstrates appropriate listening and speaking skills in personal conversations**
    b. **Demonstrates ability to choose and organize appropriate words to effectively communicate**

    c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
    d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
    e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
    f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
    g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

  1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    a. Demonstrates ability to objectively assess personal strengths and weaknesses
    b. Demonstrates ability to set realistic short-term and long-term goals
    c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
    d. Demonstrates ability to identify potential pitfalls and take evasive actions
    e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
    f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
    g. Demonstrates maturity in taking responsibility for decisions

  2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    a. Demonstrates ability to detect problem through observation, inquiry, or directive
    b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    c. Demonstrates ability to generate alternatives or options for problem solution
    d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution

    - e. Demonstrates ability to initiate and effect solution
    - f. Demonstrates ability to take responsibility for outcomes
    - g. Demonstrates ability to effectively problem solve in individual, team, or group situations
  - *3.* ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    - a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
    - b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
    - c. Demonstrates ability to visually discriminate in gross and fine imagery
    - d. Demonstrates ability to visualize abstractly
    - e. Demonstrates ability to apply visual imagery to applied tasks
  - *4.* ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    - a. Demonstrates mastery of basic reading, math, and language skills through application
    - b. Demonstrates ability to translate abstract theory into practical application
    - c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
    - d. Demonstrates knowledge of good study skills and learning habits
  - *5.* ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    - a. Demonstrates use of simple logic
    - b. Demonstrates ability to distinguish relationships
    - c. Demonstrates ability to determine and isolate factors in relationships
    - d. Demonstrates and applies knowledge through practice
    - e. Recognizes that attitudes, skills, and practice are essential to productivity
    - f. Demonstrates ability to discriminate between positive and negative, and act accordingly
- C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty
  - *1.* ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*

    a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
    b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
    c. Demonstrates ability to focus on task at hand and work to completion
    d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
    e. Demonstrates maturity to take responsibility for actions
    f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
    a. Presents a positive attitude toward tasks
    b. Demonstrates ability to separate work and personal behaviors
    c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
    d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
    e. Demonstrates ability to accept and use constructive criticism
    f. Accepts positive reinforcement in an appropriate manner
3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. Demonstrates appropriate and acceptable social behaviors in interactions
    b. Demonstrates ability to work cooperatively in individual, team, or group situations
    c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
    d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. Accepts personal strengths and weaknesses and uses the same for positive advancement

   b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   c. Demonstrates ability to formulate and follow personal schedules
   d. Demonstrates ability to wisely use classroom time
   e. Demonstrates use of good study habits and skills
   f. Demonstrates maturity to take responsibility for own actions

5. *Integrity/Honesty: Chooses ethical courses of action*
   a. Knows and demonstrates ability to distinguish between positive and negative behaviors
   b. Demonstrates honesty and integrity in working with peers and supervisors
   c. Takes full responsibility for personal actions
   d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
   e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
   MFG-A1 through MFG-A5;
   MFG-A7;
   MFG-B1 through MFG-B5;
   MFG-B7;
   MFG-C1 through MFG-C4;
   MFG-C7;
   MFG-D1 through MFG-D4;
   MFG-E1 through MFG-E5;
   MFG-F1 through MFG-F5; and,
   MFG-F7.
2. *Machinery's Handbook*, Industrial Press, Latest Edition
3. *Technology of Machine Tools*, McGraw Hill Publishers, Latest Edition

DDT 104

MASTER PROGRAM

Drafting Principles

COURSE SYLLABUS

Total lecture hours: 24 **Total lab hours: 48** **Credit hours: 3**

COURSE DESCRIPTION:

Consists of basic exercises in lettering, use of the instruments, technical sketching, geometric construction, orthographic projection, auxiliary views, and dimensioning. Working drawings will be made.

PREREQUISITES: NONE

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Form freehand vertical Gothic upper-case letters and numerals of correct shape and space without copying from an example;
2. Execute the alphabet of lines correctly, producing dense black lines of uniform thickness and spacing without a scale;
3. Demonstrate proficiency with the following scales: architect 80%, metric 75% and civil engineer's 90%;
4. Execute geometric constructions with no mistakes in tangent points, line quality or layout work;
5. Accurately draw the missing view or line in a multi view drawing, with no more than two errors in line and view construction;
6. Make or complete a sectional instrument drawing, given one or more views, with no more than two errors in line and view construction; and,
7. When provided with the necessary basic information, the student will develop satisfactory working drawings of simple machine components. This will include all the necessary views and dimensions for complete shape and size description of detail parts.

REQUIRED COURSE MATERIALS:

Textbook: *Technical Drawing*, Spencer, Giesecke, Mitchell, Hill, Latest Edition

Workbook: *Technical Drawing Problems*, Spencer, Giesecke, Mitchell, Hill, Latest Edition

Materials:
Drafting Kit No. 1 or the equivalent:
10" Triangles:
1 - 45°
1- 30°/60°
Engineer's Scale
Metric Scale
Ames Lettering Guide
Eraser Holder with erasers
Drafting Dots
Circle Template (Combination English or SAE and Metric)
Sandpaper Pointer
Erasing Shield
Bow Compass
Dusting Brush
Lead Pointer
Irregular Curve
Mechanical Pencils with refills:
.5mm
.7mm
.9mm
Lead Holder - 2mm
Leads:
.5mm - HB
.7mm - H, HB
.9mm - HB
2mm 4H, H, F
Hard Carrying Case
8½" x 11" vellum (10 sheets)

Additional items not included in kit:
4 - 17 x 22 (C size) vellum
1 - Preprinted 22 x 34 (D size) vellum

METHODS OF INSTRUCTION:

Lecture:	Classroom presentations will include lecture, video and demonstrations. Computer aided instruction may be used.
Laboratory:	Laboratory will be a hands–on drawing process using appropriate tools and media.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments including writing assignments;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all safety regulations as stated in the class policies.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to Course	
Required Materials and Tests	
Class Policies and Safety Concerns	
Function of Drafting in Design and Production	
Drafting Instruments, Material and Equipment	
Lettering	
Quiz	
Alphabet of Lines	
Types of Pencils and Leads	
Scales - Engineering and Metric	
Quiz	
Geometric Constructions	
Angle Measurements	
Theory of Third Angle Orthographic Projection	
Theory of First Angle Orthographic Projection	
Arrangement of Views	
Common Dimensions Between Views	
Quiz	
Function of Sectional Views	
Cutting Planes	
Conventional Representations	
Classifications of Sections	
Quiz	
Dimensioning Concepts	
Dimensioning Techniques	

Selection and Placement of Dimensions
Metric Dimensioning
Final Exam

Total Lecture Hours 24

LAB OUTLINE:

Lab Topics	Contact Hrs.
Using Drafting Instruments, Materials and Equipment	2
Applying Lettering	2
Delineating Alphabet of Lines	2
Selecting and Using Pencils and Leads	1
Using Scales	2
Developing Geometric Constructions	12
Using Angle Measurement	1
Using Third Angle Orthographic Projection	6
Using First Angle Orthographic Projection	6
Arranging Views and Common Dimensions	2
Creating Sectional Planes	2
Applying Cutting Planes	2
Determine and Use Conventional Representations	1
Using Classifications of Sections	1
Applying Dimensioning	4
Applying Metric Dimensioning	1
Final Exam	1
Total Lab Hours	48

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

  A. *Resources: Identifies, organizes, plans, and allocates resources*

1. Allocates time to complete assigned tasks on schedule
2. Determine and allocates required materials and resources for meeting objectives
3. Evaluates skills, performance, and quality of work and provides feedback

B. *Interpersonal: Works with others*

1. Participates as a member of the team, contributing to group effort
2. Provide individual assistance/direction to peers as requested
3. Determines and meets expectations
4. Exercises leadership qualities to effectively communicate ideas and make decisions
5. Negotiates resources in order to accomplish objectives
6. Works well with all members of the class
7. Produces drawings to acceptable levels of quality as required

C. *Information: Acquires and uses information*

1. Acquires and evaluates information
2. Organizes and applies theories of drafting and design
3. Interprets and communicates information

D. *Systems: Understands complex inter-relationships*

1. Understands and works well with social, organizational, and technological systems
2. Monitors and corrects performance of system during operation
3. Recommends modifications to system to improve performance

E. *Technology: Works with a variety of technologies*

1. Chooses relevant procedures, tools and equipment required to produce a drawing
2. Applies appropriate procedures and techniques to accomplish tasks
3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks.

1. *Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*

   a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
   b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information

    from text and supplemental materials on a level to facilitate productive independent and group study
    c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
    d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
    e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
    a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
    b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
    c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
    d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
    e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
    b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
    c. Demonstrates ability to understand and perform multi-step computations
    d. Demonstrates ability to read, interpret, and use standard measuring devices

        - e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
        - f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
        - g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines
    - 4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
        - a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
        - b. Demonstrates ability to hear, comprehend, and appropriately follow directions
        - c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
        - d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
        - e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
        - f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed
    - 5. *Speaking: Organizes ideas and communicates orally*
        - a. Demonstrates appropriate listening and speaking skills in personal conversations
        - b. Demonstrates ability to choose and organize appropriate words to effectively communicate
        - c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
        - d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
        - e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
        - f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
        - g. Demonstrates ability to take responsibility for presentations
- B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    a. **Demonstrates ability to objectively assess personal strengths and weaknesses**
    b. **Demonstrates ability to set realistic short-term and long-term goals**
    c. **Demonstrates ability to recognize and distinguish between positive and negative alternatives**
    d. **Demonstrates ability to identify potential pitfalls and take evasive actions**
    e. **Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response**
    f. **Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives**
    g. **Demonstrates maturity in taking responsibility for decisions**
2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    a. **Demonstrates ability to detect problem through observation, inquiry, or directive**
    b. **Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation**
    c. **Demonstrates ability to generate alternatives or options for problem solution**
    d. **Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution**
    e. **Demonstrates ability to initiate and effect solution**
    f. **Demonstrates ability to take responsibility for outcomes**
    g. **Demonstrates ability to effectively problem solve in individual, team, or group situations**
3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. **Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery**
    b. **Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues**

    c. Demonstrates ability to visually discriminate in gross and fine imagery
    d. Demonstrates ability to visualize abstractly
    e. Demonstrates ability to apply visual imagery to applied tasks

  4. *Knowing How to Learn: Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. Demonstrates mastery of basic reading, math, and language skills through application
    b. Demonstrates ability to translate abstract theory into practical application
    c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
    d. Demonstrates knowledge of good study skills and learning habits

  5. *Reasoning: Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. Demonstrates use of simple logic
    b. Demonstrates ability to distinguish relationships
    c. Demonstrates ability to determine and isolate factors in relationships
    d. Demonstrates and applies knowledge through practice
    e. Recognizes that attitudes, skills, and practice are essential to productivity
    f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

  1. *Responsibility: Exerts a high level of effort and perseveres towards goal attainment*
    a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
    b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
    c. Demonstrates ability to focus on task at hand and work to completion
    d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
    e. Demonstrates maturity to take responsibility for actions

   - f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
   - a. Presents a positive attitude toward tasks
   - b. Demonstrates ability to separate work and personal behaviors
   - c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
   - d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
   - e. Demonstrates ability to accept and use constructive criticism
   - f. Accepts positive reinforcement in an appropriate manner
3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   - a. Demonstrates appropriate and acceptable social behaviors in interactions
   - b. Demonstrates ability to work cooperatively in individual, team, or group situations
   - c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
   - d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   - a. Accepts personal strengths and weaknesses and uses the same for positive advancement
   - b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   - c. Demonstrates ability to formulate and follow personal schedules
   - d. Demonstrates ability to wisely use classroom time
   - e. Demonstrates use of good study habits and skills
   - f. Demonstrates maturity to take responsibility for own actions
5. *Integrity/Honesty: Chooses ethical courses of action*
   - a. Knows and demonstrates ability to distinguish between positive and negative behaviors
   - b. Demonstrates honesty and integrity in working with peers and supervisors

c. **Takes full responsibility for personal actions**

d. **Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable**

e. **Demonstrates positive work and social ethics in undertakings**

Appropriate Reference Materials:

1. MASTER Technical Modules:
   MFG-C1 through MFG-C3.

DDT 104
01/081897

MATH 1314

MASTER PROGRAM

College Algebra

COURSE SYLLABUS

Total lecture hours: 48 **Total lab hours: 0** **Credit hours: 3**

COURSE DESCRIPTION:

Includes a study of quadratics; polynomial, rational, logarithmic, and exponential functions; systems of equations; progressions; sequences and series; matrices and determinants.

PREREQUISITE: **Intermediate Algebra or equivalent as determined by math placement exam**

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Solve linear, quadratic and absolute value equations and inequalities in one variable;
2. Define relation, function and inverse functions and graph linear, quadratic, polynomial and rational functions;
3. Solve systems of linear and nonlinear equations with two and three variables;
4. Define a matrix, perform operations with matrices, and find the inverse of a matrix;
5. Write the equation of a circle or parabola given specific characteristics and graph of both of these;
6. Determine the number of and nature of the roots of a polynomial equation and solve for them using synthetic division;
7. Define exponential and logarithmic functions, determine their properties and graphs and solve equations involving exponential and logarithmic functions; and,
8. Define the concepts of sequence and series and develop the properties for arithmetic, geometric and binomial series.

REQUIRED COURSE MATERIALS:

Textbook: *College Algebra*, Larson/Hostetler, D.C. Heath & Company, Latest Edition

Supplies: Scientific Calculator

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture and demonstrations.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete assignments;
2. Apply theory to assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments, including writing assignments and oral presentations;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all rules and safety regulations.

TENTATIVE LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to College Algebra	1
Algebraic Equations and Inequalities	8
A. Equations and Applications	
1. Linear	
2. Quadratic	
3. Other	
a. Higher Degree	
b. Radical	
c. Rational	
d. Absolute Value	
B. Complex Numbers	
C. Inequalities	
1. Linear	
2. Quadratic	
3. Cubic	
4. Rational	
5. Absolute value	
Functions and Graphs	9
A. The Cartesian Plane	
B. Graphing an Equation	
C. Lines in the Plane	
D. Functions	

    1. Definition and Notation
    2. Graphs - include parabola
    3. Combinations
        a. Operations
        b. Composition
    4. Inverse

Polynomial and Rational Functions: Graphs and Zeros 10

- A. Graphing and Finding Zeros
    1. Quadratic
    2. Higher Degree
- B. Polynomial and Synthetic Division
- C. Real Zeros
    1. Descarte's Rule of Signs
    2. Rational Zero Test
    3. Bounds
- D. Complex Zeros and the Fundamental Theorem of Algebra
- E. Approximation Techniques for Zeros
- F. Graphing Rational Functions

Exponential and Logarithmic Functions 7

- A. Exponential Functions
    1. Graphing
    2. Natural Base e
    3. Applications
- B. Logarithmic Functions
    1. Graphing
    2. Natural Logarithmic Functions
    3. Change of Base
- C. Properties of Logarithms
- D. Solving Exponential and Logarithmic Equations
- E. Applications

Systems of Equations and Matrices 6

- A. Systems and Equations in Two Variables
    1. Graphing
    2. Substitution
    3. Elimination
- B. Systems of Linear Equations in more than Two Variables
    1. Elimination in Row - echelon form
    2. Gaussian Elimination
    3. Gauss-Jordan Elimination
- C. Operations with Matrices
- D. The Inverse of a Matrix

Sequence and Series 6

A. Sequence and Summation
B. Arithmetic Sequences
C. Geometric Sequences and Series
D. The Binomial Theorem

Final Exam		2
	Total Lecture Hours	**48**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

- ***A. Resources:* *Identifies, organizes, plans, and allocates resources***
  1. **Allocates time to complete assigned tasks on schedule**
  2. **Determines and allocates required materials and resources for meeting objectives**
  3. **Evaluates skills, performance, and quality of work and provides feedback**
- ***B. Interpersonal: Works with others***
  1. **Participates as a member of the team, contributing to group effort**
  2. **Provides individual assistance/direction to peers as requested**
  3. **Determines and meets expectations**
  4. **Exercises leadership qualities to effectively communicate ideas and make decisions.**
  5. **Negotiates resources in order to accomplish objectives**
  6. **Works well with all members of the class**
- ***C. Information: Acquires and uses information***
  1. **Acquires and evaluates information**
  2. **Organizes and maintains information**
  3. **Interprets and communicates information**
- ***D. Systems: Understands complex inter-relationships***

1. Understands and works well with social, organizational, and technological systems
2. Monitors and corrects performance of system during operation
3. Recommends modifications to system to improve performance

E. Technology: Works with a variety of technologies

1. Chooses relevant procedures, tools, and equipment
2. Applies appropriate procedures and techniques to accomplish tasks
3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

A. Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks

*1. **Reading:** Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*

a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts

b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study

c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)

d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner

e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

*2. **Writing:** Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*

a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning

b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.

- c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
- d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
- e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   - a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
   - b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
   - c. Demonstrates ability to understand and perform multi-step computations
   - d. Demonstrates ability to read, interpret, and use standard measuring devices
   - e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
   - f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
   - g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines
4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
   - a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
   - b. Demonstrates ability to hear, comprehend, and appropriately follow directions
   - c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
   - d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
   - e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds

        - f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed
    - 5. *Speaking: Organizes ideas and communicates orally*
        - a. Demonstrates appropriate listening and speaking skills in personal conversations
        - b. Demonstrates ability to choose and organize appropriate words to effectively communicate
        - c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
        - d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
        - e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
        - f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
        - g. Demonstrates ability to take responsibility for presentations
- B. Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons
    - 1. ***Decision Making:** Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
        - a. Demonstrates ability to objectively assess personal strengths and weaknesses
        - b. Demonstrates ability to set realistic short-term and long-term goals
        - c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
        - d. Demonstrates ability to identify potential pitfalls and take evasive actions
        - e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
        - f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
        - g. Demonstrates maturity in taking responsibility for decisions
    - 2. ***Problem Solving:** Recognizes problems and devises and implements plan of action*
        - a. Demonstrates ability to detect problem through observation, inquiry, or directive

- b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
- c. Demonstrates ability to generate alternatives or options for problem solution
- d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
- e. Demonstrates ability to initiate and effect solution
- f. Demonstrates ability to take responsibility for outcomes
- g. Demonstrates ability to effectively problem solve in individual, team, or group situations

3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
- a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
- b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
- c. Demonstrates ability to visually discriminate in gross and fine imagery
- d. Demonstrates ability to visualize abstractly
- e. Demonstrates ability to apply visual imagery to applied tasks

4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
- a. Demonstrates mastery of basic reading, math, and language skills through application
- b. Demonstrates ability to translate abstract theory into practical application
- c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
- d. Demonstrates knowledge of good study skills and learning habits

5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
- a. Demonstrates use of simple logic
- b. Demonstrates ability to distinguish relationships
- c. Demonstrates ability to determine and isolate factors in relationships
- d. Demonstrates and applies knowledge through practice

        e. Recognizes that attitudes, skills, and practice are essential to productivity
        f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

    1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
        a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
        b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
        c. Demonstrates ability to focus on task at hand and work to completion
        d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
        e. Demonstrates maturity to take responsibility for actions
        f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

    2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
        a. Presents a positive attitude toward tasks
        b. Demonstrates ability to separate work and personal behaviors
        c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
        d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
        e. Demonstrates ability to accept and use constructive criticism
        f. Accepts positive reinforcement in an appropriate manner

    3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
        a. Demonstrates appropriate and acceptable social behaviors in interactions
        b. Demonstrates ability to work cooperatively in individual, team, or group situations
        c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner

d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly

4. ***Self-Management:** Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   - a. Accepts personal strengths and weaknesses and uses the same for positive advancement
   - b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   - c. Demonstrates ability to formulate and follow personal schedules
   - d. Demonstrates ability to wisely use classroom time
   - e. Demonstrates use of good study habits and skills
   - f. Demonstrates maturity to take responsibility for own actions
5. ***Integrity/Honesty:** Chooses ethical courses of action*
   - a. Knows and demonstrates ability to distinguish between positive and negative behaviors
   - b. Demonstrates honesty and integrity in working with peers and supervisors
   - c. Takes full responsibility for personal actions
   - d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
   - e. Demonstrates positive work and social ethics in undertakings

ENGL 1301

MASTER PROGRAM

Composition I

COURSE SYLLABUS

Total lecture hours: 48 **Total lab hours: 0** **Credit hours: 3**

COURSE DESCRIPTION:

Includes the process of composing essays, including pre-writing techniques, drafting, and revising and editing. Students write several essays of various types, in both in–class and out–of–class settings. Students critically analyze sample student and professional essays.

PREREQUISITE: **Writing Skills II or equivalent as determined by the English placement test**

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Select a clearly defined subject and address it to a specific audience in a logical manner;
2. Develop a unified and coherent theme that uses standard American grammar;
3. Use a handbook and a dictionary as resources for writing;
4. Compose written assignments using various strategies of informative and persuasive prose;
5. Compose well organized answers to questions posed on written examinations; and,
6. Critically analyze assigned essays.

REQUIRED COURSE MATERIALS:

Textbook: *Strategies for Successful Writing,* Reinking, James A., and Hart, Andrew W., Englewood Cliffs, N. J.: Prentice-Hall, Latest Edition

Supplies:
College Level Dictionary
Large package of Notebook Paper
Liquid Paper (one bottle)
Ballpoint pens (blue or black)

#2 Pencils
Package of Scantron Forms
Computer diskette

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete assignments;
2. Apply theory to assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments, including writing assignments, and oral presentations;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all rules and safety regulations.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Orientation	2
A. Initial Writing Assignment	
B. Testing	
Paragraph to Essay	5
A. Purpose and Audience	
B. Planning and Organization of a Paragraph	
C. Expanding the Paragraph to an Essay	
D. Peer Editing	
Types of Compositions	27
A. Description	
B. Process *	
C. Comparison - Analogy *	
D. Classification *	
E. Cause and Effect *	
F. In–class Essay	
Practical Applications	10
A. Essay Examinations	
B. Critical Analysis	

Conclusion 4

A. Preparation for Final Exam
B. Final Exam (required in order to receive a passing grade in the course)
C. Student Conferences

Total Lecture Hours 48

*** may be persuasive or informative**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
  A. Resources: Identifies, organizes, plans, and allocates resources
    1. Allocates time to complete assigned tasks on schedule
    2. Determines and allocates required materials and resources for meeting objectives
    3. Evaluates skills, performance, and quality of work and provides feedback
  B. Interpersonal: Works with others
    1. Participates as a member of the team, contributing to group effort
    2. Provides individual assistance/direction to peers as requested
    3. Determines and meets expectations
    4. Exercises leadership qualities to effectively communicate ideas and make decisions.
    5. Negotiates resources in order to accomplish objectives
    6. Works well with all members of the class
  C. Information: Acquires and uses information
    1. Acquires and evaluates information
    2. Organizes and maintains information

3. Interprets and communicates information

D. Systems: Understands complex inter-relationships

1. Understands and works well with social, organizational, and technological systems
2. Monitors and corrects performance of system during operation
3. Recommends modifications to system to improve performance

E. Technology: Works with a variety of technologies

1. Chooses relevant procedures, tools, and equipment
2. Applies appropriate procedures and techniques to accomplish tasks
3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks

1. Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules

a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts

b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study

c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)

d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner

e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts

a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning

   b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
   c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
   d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
   e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. ***Arithmetic/Mathematics:** Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
   b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
   c. Demonstrates ability to understand and perform multi-step computations
   d. Demonstrates ability to read, interpret, and use standard measuring devices
   e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
   f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
   g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines

4. ***Listening:** Receives, attends to, interprets, and responds to verbal messages and other cues*
   a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
   b. Demonstrates ability to hear, comprehend, and appropriately follow directions
   c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction

        - d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
        - e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
        - f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed
    - 5. *Speaking: Organizes ideas and communicates orally*
        - a. Demonstrates appropriate listening and speaking skills in personal conversations
        - b. Demonstrates ability to choose and organize appropriate words to effectively communicate
        - c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
        - d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
        - e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
        - f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
        - g. Demonstrates ability to take responsibility for presentations
- B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons
    - 1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
        - a. Demonstrates ability to objectively assess personal strengths and weaknesses
        - b. Demonstrates ability to set realistic short-term and long-term goals
        - c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
        - d. Demonstrates ability to identify potential pitfalls and take evasive actions
        - e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
        - f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
        - g. Demonstrates maturity in taking responsibility for decisions

2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    a. Demonstrates ability to detect problem through observation, inquiry, or directive
    b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    c. Demonstrates ability to generate alternatives or options for problem solution
    d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    e. Demonstrates ability to initiate and effect solution
    f. Demonstrates ability to take responsibility for outcomes
    g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
    b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
    c. Demonstrates ability to visually discriminate in gross and fine imagery
    d. Demonstrates ability to visualize abstractly
    e. Demonstrates ability to apply visual imagery to applied tasks
4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. Demonstrates mastery of basic reading, math, and language skills through application
    b. Demonstrates ability to translate abstract theory into practical application
    c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
    d. Demonstrates knowledge of good study skills and learning habits
5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. Demonstrates use of simple logic
    b. Demonstrates ability to distinguish relationships

c. Demonstrates ability to determine and isolate factors in relationships

d. Demonstrates and applies knowledge through practice

e. Recognizes that attitudes, skills, and practice are essential to productivity

f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*

a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals

b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner

c. Demonstrates ability to focus on task at hand and work to completion

d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time

e. Demonstrates maturity to take responsibility for actions

f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*

a. Presents a positive attitude toward tasks

b. Demonstrates ability to separate work and personal behaviors

c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors

d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors

e. Demonstrates ability to accept and use constructive criticism

f. Accepts positive reinforcement in an appropriate manner

3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*

a. Demonstrates appropriate and acceptable social behaviors in interactions

b. Demonstrates ability to work cooperatively in individual, team, or group situations

   c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
   d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly

4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   a. Accepts personal strengths and weaknesses and uses the same for positive advancement
   b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   c. Demonstrates ability to formulate and follow personal schedules
   d. Demonstrates ability to wisely use classroom time
   e. Demonstrates use of good study habits and skills
   f. Demonstrates maturity to take responsibility for own actions
5. ***Integrity/Honesty:*** *Chooses ethical courses of action*
   a. Knows and demonstrates ability to distinguish between positive and negative behaviors
   b. Demonstrates honesty and integrity in working with peers and supervisors
   c. Takes full responsibility for personal actions
   d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
   e. Demonstrates positive work and social ethics in undertakings

MASTER Curriculum
Manufacturing Technology
(Associate of Applied Science Degree Program)

First Quarter*		LEC	LAB	CR
PSYC 1100	College Success Skills	1	0	1
MFG 100	Machine Tool Practices I	3	9	6
DDT 104	Drafting Principles	2	4	3
MATH 1314	College Algebra	4	0	3
ENGL 1301	Composition I	4	0	3
		14	13	16
Second Quarter*				
MFG 200	Machine Tool Practices II	3	9	6
ENGL 134	Interpersonal Communication	4	0	3
MATH 1316	Plane Trigonometry	4	0	3
CNS 2060	Application Software	1	4	3
		12	13	15
Third Quarter*				
MFG 112	Engineering Materials	2	3	3
OSH 216	Safety and Accident Prevention	2	3	3
PHY 114	Fluid Power I	3	3	4
EST 120	Electrical Applications	3	3	4
WLT 105	Survey of Welding Processes & Applications	3	3	4
		13	15	18
Fourth Quarter*				
MFG 205	CNC Machine Programming	3	3	4
MFG 206	Statics	3	3	4
MFG 301	Manufacturing Processes	3	3	4
DDT 128	Introduction to Computer Drafting	1	4	2
PSYC 2301	General Psychology	4	0	3
		14	13	17
FIFTH QUARTER*				
MFG 302	CAD/CAM I	3	3	4
MFG 216	Tool Design I	2	6	4
MFG 312	Strength of Materials	3	3	4
PHYS 1310	Fundamentals of Physics	4	0	3
	Free Elective	2	0	2
		14	12	17
Sixth Quarter*				
MFG 318	CAD/CAM II	3	3	4
MFG 315	Computer Integrated Manufacturing	2	2	3
MFG 324	Quality Assurance & Statistical Process Control	2	3	3
MFG 322	Engineering Technology Project	4	6	6
		11	14	16
	Program Totals	78	80	99

*** Each quarter is 12 weeks in length**

MASTER PROGRAM

Machine Tool Practices II

COURSE SYLLABUS

Total lecture hours: 36 **Total lab hours: 108** **Credit hours: 6**

COURSE DESCRIPTION:

Develops additional machining skills for those students who have the basic skills that were developed in Machine Tool Practices I.

The student will work from more complex engineering drawings and use the engine lathe and milling machines to produce parts that will assemble into a functioning machine. Precision work and the control of surface finishes will be stressed. The engine lathe will be used to turn, taper, thread, bore, ream, and knurl several parts. The milling machine will be used to cut keyways, mill precise angles, and bore holes. The safe operation and maintenance of the machine shop will also be an important objective.

PREREQUISITES: Machine Tool Practices I

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Perform advanced machine shop operations;
2. Work from more complex engineering drawings;
3. Use the engine lathe and milling machine to produce parts that will assemble into a functioning machine;
4. Perform precision work and control of surface finishes;
5. Use the engine lathe to turn, taper, thread, bore, ream, and knurl several parts;
6. Use the milling machines (vertical and horizontal) to cut key ways, mill precise angles and bore holes; and,
7. Practice safe operation and maintenance of a machine shop.

REQUIRED COURSE MATERIALS:

Textbook: *Machine Tool Practices*, Kibbe, Neely, and Meyer, Wiley Pub., Latest Edition

Lab Manual: *Machine Tool Practices II*, Raborn, TSTC Pub., Latest Edition

Student Tool List: The hand tools required in Machine Tool Practices I are also required for Machine Tool Practices II.

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Laboratory: Laboratory will be a hands–on machining process.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Perform on written, oral, or practical examinations;
4. Perform on outside assignments including writing assignments;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all shop rules and safety regulations as stated in the laboratory manual.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to the Course	1
Safety in the Machine Shop	1
Gages	1
Lathe Parts	1
Lathe Accessories	1
Cutting Speeds and Feeds	1
Aligning Centers	1
Machining Between Centers	1
Knurling and Grooving	1
QUIZ I (over the above units)	1
Tapers	2
Threads	3
Using Chucks	1
Drilling and Boring	1
Milling Machines	1
QUIZ 2 (over the above units)	1
Milling Cutters	1

Cutting Speeds	1
Milling Operations	1
Indexing	2
Gears	1
Gear Cutting	1
Assembly of Jig Saw	3
QUIZ 3 (over the above units)	1
Oral Presentations*	6
Total Lecture Hours	**36**

* *(15-20 minute student presentations on assigned machine-related topics. These topics could include future trends or special concerns of the machine tool industry.)*

LAB OUTLINE:

Lab Topics	Contact Hrs.
Shop orientation and safety	1
Precision layout	4
Precision measuring with gage blocks and sine bar	8
Lathe work	27
Vertical milling machine work	18
Horizontal milling machine	6
Bench work	27
Assembly of machined parts	6
Testing of completed machine	6
Leaving the shop in order	5
Total Lab Hours	**108**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

- A. *Resources: Identifies, organizes, plans, and allocates resources*
  - 1. Allocates time to complete assigned tasks on schedule
  - 2. Determines and allocates required materials and resources for meeting objectives
  - 3. Evaluates skills, performance, and quality of work and provides feedback
- B. *Interpersonal: Works with others*
  - 1. Participates as a member of the team, contributing to group effort
  - 2. Provides individual assistance/direction to peers as requested
  - 3. Determines and meets expectations
  - 4. Exercises leadership qualities to effectively communicate ideas and make decisions.
  - 5. Negotiates resources in order to accomplish objectives
  - 6. Works well with all members of the class
- C. *Information: Acquires and uses information*
  - 1. Acquires and evaluates information
  - 2. Organizes and maintains information
  - 3. Interprets and communicates information
- D. *Systems: Understands complex inter-relationships*
  - 1. Understands and works well with social, organizational, and technological systems
  - 2. Monitors and corrects performance of system during operation
  - 3. Recommends modifications to system to improve performance
- E. *Technology: Works with a variety of technologies*
  - 1. Chooses relevant procedures, tools, and equipment
  - 2. Applies appropriate procedures and techniques to accomplish tasks
  - 3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

- A. Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks
  - *1. Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
    - a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
    - b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information

from text and supplemental materials on a level to facilitate productive independent and group study

   c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
   d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
   e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
   b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
   c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
   d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
   e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
   b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
   c. Demonstrates ability to understand and perform multi-step computations
   d. Demonstrates ability to read, interpret, and use standard measuring devices

e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines

*4. **Listening:** Receives, attends to, interprets, and responds to verbal messages and other cues*
a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
b. Demonstrates ability to hear, comprehend, and appropriately follow directions
c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed

*5. **Speaking**: Organizes ideas and communicates orally*
a. Demonstrates appropriate listening and speaking skills in personal conversations
b. Demonstrates ability to choose and organize appropriate words to effectively communicate
c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    a. Demonstrates ability to objectively assess personal strengths and weaknesses
    b. Demonstrates ability to set realistic short-term and long-term goals
    c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
    d. Demonstrates ability to identify potential pitfalls and take evasive actions
    e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
    f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
    g. Demonstrates maturity in taking responsibility for decisions
2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    a. Demonstrates ability to detect problem through observation, inquiry, or directive
    b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    c. Demonstrates ability to generate alternatives or options for problem solution
    d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    e. Demonstrates ability to initiate and effect solution
    f. Demonstrates ability to take responsibility for outcomes
    g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
    b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues

        - c. Demonstrates ability to visually discriminate in gross and fine imagery
        - d. Demonstrates ability to visualize abstractly
        - e. Demonstrates ability to apply visual imagery to applied tasks
    - *4.* ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
        - a. Demonstrates mastery of basic reading, math, and language skills through application
        - b. Demonstrates ability to translate abstract theory into practical application
        - c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
        - d. Demonstrates knowledge of good study skills and learning habits
    - *5.* ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
        - a. Demonstrates use of simple logic
        - b. Demonstrates ability to distinguish relationships
        - c. Demonstrates ability to determine and isolate factors in relationships
        - d. Demonstrates and applies knowledge through practice
        - e. Recognizes that attitudes, skills, and practice are essential to productivity
        - f. Demonstrates ability to discriminate between positive and negative, and act accordingly
- C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty
    - *1.* ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
        - a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
        - b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
        - c. Demonstrates ability to focus on task at hand and work to completion
        - d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
        - e. Demonstrates maturity to take responsibility for actions

    - f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
    - a. Presents a positive attitude toward tasks
    - b. Demonstrates ability to separate work and personal behaviors
    - c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
    - d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
    - e. Demonstrates ability to accept and use constructive criticism
    - f. Accepts positive reinforcement in an appropriate manner
3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    - a. Demonstrates appropriate and acceptable social behaviors in interactions
    - b. Demonstrates ability to work cooperatively in individual, team, or group situations
    - c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
    - d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    - a. Accepts personal strengths and weaknesses and uses the same for positive advancement
    - b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
    - c. Demonstrates ability to formulate and follow personal schedules
    - d. Demonstrates ability to wisely use classroom time
    - e. Demonstrates use of good study habits and skills
    - f. Demonstrates maturity to take responsibility for own actions
5. *Integrity/Honesty: Chooses ethical courses of action*
    - a. Knows and demonstrates ability to distinguish between positive and negative behaviors
    - b. Demonstrates honesty and integrity in working with peers and supervisors

c. Takes full responsibility for personal actions
d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
    MFG-A1 through MFG-A5;
    MFG-A7;
    MFG-B1 through MFG-B12;
    MFG-C1 through MFG-C8;
    MFG-D1 through MFG-D2;
    MFG-D4;
    MFG-E1 through MFG-E4;
    MFG-E6; and,
    MFG-F1 through MFG-F7.
2. *Machinery's Handbook*, Industrial Press, Latest Edition
3. *Technology of Machine Tools*, McGraw Hill Publishers, Latest Edition

ENGL 134

MASTER PROGRAM

Interpersonal Communications

COURSE SYLLABUS

Total lecture hours: 48 **Total lab hours: 0** **Credit hours: 3**

COURSE DESCRIPTION:

Introduces theories and exercises in verbal and nonverbal communication with focus on interpersonal relationships, the study of internal and external factors that impact communication, communication clarification, and conflict resolution. Various presentations are required.

PREREQUISITE: **Composition I**

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Employ models to demonstrate communication effectiveness;
2. Develop a self-concept that enhances communication;
3. Engage in effective perception-checking;
4. Distinguish between debilitative and facilitative emotions and demonstrate; methods for managing them;
5. Recognize the role of nonverbal behavior in decoding messages;
6. Demonstrate the use of several effective listening response styles;
7. Identify and describe key aspects of interpersonal relationships;
8. Use feedback to confirm messages;
9. Demonstrate non-defensive responses to criticism; and,
10. Demonstrate the ability to make effective oral presentations.

REQUIRED COURSE MATERIALS:

Textbook: *Understanding Human Communication,* Alder, Ronald B., and George Rodman, New York: HBJ, Latest Edition

SUPPLIES:
Notebook paper
Spiral notebook
Ball point pens (black)
Pencils #2
Scantron forms
Liquid paper

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete assignments;
2. Apply theory to assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments, including writing assignments, and oral presentations;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all rules and safety regulations.

LECTURE OUTLINE

Lecture Topics	Contact Hrs.
Orientation	2
Booklists	
Course Expectations	
Autograph Party	
A First Look at Interpersonal Relationships	4
A First Look	
Class Response (discussion)	
Coat of Arms (or Bag Speech)	
Evaluation	
The Self-Concept: Key to Communication	4
Examination of the Self-Concept	
Class Response (discussion)	
Presentations	
Evaluation	
Perception: What you see is what you get.	4
Lecture on Perception	
Class Response (discussion)	
Presentations	
Evaluation	
Emotions: Thinking and Feeling	4
Lecture on Emotions	
Class Response (discussion)	
Presentations	

Evaluation	
Midterm Exam	2
Nonverbal Communication	4
Lecture on Nonverbal Communication	
Class Response (discussion)	
Presentations	
Evaluation	
Listening vs. Hearing	6
Lecture on Listening	
Class Response (discussion)	
Presentations	
Evaluation	
Intimacy and Distance in Relationships	4
Lecture on Interpersonal Relationships	
Class Response (discussion)	
Presentations or other activity	
Evaluation	
Improving Communications Climates	4
Lecture on Communication Climates	
Class Response (discussion)	
Presentations or other activity	
Evaluation	
Resolving Interpersonal Conflicts	6
Lecture on Resolving Conflicts	
Class Response	
Presentations or other activity	
Evaluation	
OR	
A movie that incorporates interpersonal concepts	
Movie (1st 50 minutes)	
Movie (2nd 50 minutes)	
Complete movie	
Discuss movie	
Final Exam	2
Completion of Course, Student Conferences; Course Wrap–Up	2
Total Lecture Hours	**48**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, *full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."*

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
   - A. ***Resources:*** *Identifies, organizes, plans, and allocates resources*
     - 1. Allocates time to complete assigned tasks on schedule
     - 2. Determines and allocates required materials and resources for meeting objectives
     - 3. Evaluates skills, performance, and quality of work and provides feedback
   - B. ***Interpersonal:*** *Works with others*
     - 1. Participates as a member of the team, contributing to group effort
     - 2. Provides individual assistance/direction to peers as requested
     - 3. Determines and meets expectations
     - 4. Exercises leadership qualities to effectively communicate ideas and make decisions.
     - 5. Negotiates resources in order to accomplish objectives
     - 6. Works well with all members of the class
   - C. ***Information:*** *Acquires and uses information*
     - 1. Acquires and evaluates information
     - 2. Organizes and maintains information
     - 3. Interprets and communicates information
   - D. ***Systems:*** *Understands complex inter-relationships*
     - 1. Understands and works well with social, organizational, and technological systems
     - 2. Monitors and corrects performance of system during operation
     - 3. Recommends modifications to system to improve performance
   - E. ***Technology:*** *Works with a variety of technologies*
     - 1. Chooses relevant procedures, tools, and equipment
     - 2. Applies appropriate procedures and techniques to accomplish tasks
     - 3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS
   - A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks

1. ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
    a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
    b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
    c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
    d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
    e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials
2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
    a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
    b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
    c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
    d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
    e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments
3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*

- a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
- b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
- c. Demonstrates ability to understand and perform multi-step computations
- d. Demonstrates ability to read, interpret, and use standard measuring devices
- e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
- f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
- g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines

4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
   - a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
   - b. Demonstrates ability to hear, comprehend, and appropriately follow directions
   - c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
   - d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
   - e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
   - f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed
5. *Speaking: Organizes ideas and communicates orally*
   - a. Demonstrates appropriate listening and speaking skills in personal conversations
   - b. Demonstrates ability to choose and organize appropriate words to effectively communicate
   - c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation

        - d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
        - e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
        - f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
        - g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    - a. Demonstrates ability to objectively assess personal strengths and weaknesses
    - b. Demonstrates ability to set realistic short-term and long-term goals
    - c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
    - d. Demonstrates ability to identify potential pitfalls and take evasive actions
    - e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
    - f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
    - g. Demonstrates maturity in taking responsibility for decisions
2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    - a. Demonstrates ability to detect problem through observation, inquiry, or directive
    - b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    - c. Demonstrates ability to generate alternatives or options for problem solution
    - d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    - e. Demonstrates ability to initiate and effect solution
    - f. Demonstrates ability to take responsibility for outcomes

g. Demonstrates ability to effectively problem solve in individual, team, or group situations

3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
   - a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
   - b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
   - c. Demonstrates ability to visually discriminate in gross and fine imagery
   - d. Demonstrates ability to visualize abstractly
   - e. Demonstrates ability to apply visual imagery to applied tasks
4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
   - a. Demonstrates mastery of basic reading, math, and language skills through application
   - b. Demonstrates ability to translate abstract theory into practical application
   - c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
   - d. Demonstrates knowledge of good study skills and learning habits
5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   - a. Demonstrates use of simple logic
   - b. Demonstrates ability to distinguish relationships
   - c. Demonstrates ability to determine and isolate factors in relationships
   - d. Demonstrates and applies knowledge through practice
   - e. Recognizes that attitudes, skills, and practice are essential to productivity
   - f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
   - a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals

   - b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
   - c. Demonstrates ability to focus on task at hand and work to completion
   - d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
   - e. Demonstrates maturity to take responsibility for actions
   - f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
   - a. Presents a positive attitude toward tasks
   - b. Demonstrates ability to separate work and personal behaviors
   - c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
   - d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
   - e. Demonstrates ability to accept and use constructive criticism
   - f. Accepts positive reinforcement in an appropriate manner
3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   - a. Demonstrates appropriate and acceptable social behaviors in interactions
   - b. Demonstrates ability to work cooperatively in individual, team, or group situations
   - c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
   - d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   - a. Accepts personal strengths and weaknesses and uses the same for positive advancement
   - b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   - c. Demonstrates ability to formulate and follow personal schedules

    d. Demonstrates ability to wisely use classroom time
    e. Demonstrates use of good study habits and skills
    f. Demonstrates maturity to take responsibility for own actions

5. *Integrity/Honesty: Chooses ethical courses of action*
    a. Knows and demonstrates ability to distinguish between positive and negative behaviors
    b. Demonstrates honesty and integrity in working with peers and supervisors
    c. Takes full responsibility for personal actions
    d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
    e. Demonstrates positive work and social ethics in undertakings

ENGL 134
01/061297

MATH 1316

MASTER PROGRAM

Plane Trigonometry

COURSE SYLLABUS

Total lecture hours: 48 **Total lab hours: 0** **Credit hours: 3**

COURSE DESCRIPTION:

Includes topics in trigonometric functions, right triangles, trigonometric identities, radian measure, graphs of periodic functions, and oblique triangles.

PREREQUISITE: College Algebra

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Find the distance between two points;
2. Define the trigonometric functions;
3. Solve right triangles;
4. Find the function values of any angle;
5. State and use fundamental relationships of trigonometric functions;
6. Graph trigonometric functions;
7. Verify trigonometric identities;
8. Solve trigonometric equations;
9. Graph the inverse sine, cosine, and tangent functions;
10. Solve oblique triangles by the Law of Sines and the Law of Cosines;
11. Perform operations on the set of complex numbers in both rectangular and polar form;
12. Graph complex numbers; and,
13. Solve applied problems using vectors, radian measure, linear and angular velocity, arc length, area of a sector, trigonometric equations, and inverse functions.

REQUIRED COURSE MATERIALS:

Textbook: *Trigonometry*, Lial, Miller, & Hornsby, Scott Foresman Pub., Latest Edition

Supplies:
Notebook Paper
Pencils
Scientific Calculator
Scantron form 882 w/100 answers

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete assignments;
2. Apply theory to assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments, including writing assignments, and oral presentations;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all rules and safety regulations.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to College Algebra	1
The Trigonometric Functions	11
A. Basic Terms of Trigonometry	
B. Definitions of the Trigonometric Functions	
C. Trigonometric Functions of Acute Angles	
D. Trigonometric Functions of Special Angles	
E. Using Reference Angles and the Trigonometric Tables	
F. Solving Right Triangles	
G. Applications of Right Triangles	
Radian Measure	5
A. Radian Measure Conversions	
B. Formulae for Arc Length and Area of a Sector	
C. Linear and Angular Velocity Formulae	
D. Circular Functions of Real Numbers	
Graphs of Trigonometric Functions	5
A. Graphs of the Sine and Cosine Functions	
B. Horizontal Translations: Phase Shift	
C. Graphs of other Trigonometric Functions	

Trigonometric Identities	7
A. Fundamental Identities	
B. Verifying Trigonometric Identities	
C. Identities Involving Sums and Differences of Two Angles	
D. Double and Half-Angle Identities	
Inverse Trigonometric Functions and Trigonometric Equations	4
A. Inverse Functions	
B. Inverse Trigonometric Functions	
C. Trigonometric Equations	
D. Inverse Trigonometric Equations	
Oblique Triangles and Vectors	7
A. Law of Sines	
B. The Ambiguous Case: SSA	
C. Law of Cosines	
D. Vector Applications	
Complex Numbers and Polar Coordinates	6
A. Operations with Complex Numbers	
B. Trigonometric Form of a Complex Number	
C. Product and Quotient Theorems	
D. Powers and Roots of Complex Numbers	
Final Exam	2
Total Lecture Hours	48

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

A. *Resources:* *Identifies, organizes, plans, and allocates resources*

1. Allocates time to complete assigned tasks on schedule
2. Determines and allocates required materials and resources for meeting objectives
3. Evaluates skills, performance, and quality of work and provides feedback

B. *Interpersonal: Works with others*

1. Participates as a member of the team, contributing to group effort
2. Provides individual assistance/direction to peers as requested
3. Determines and meets expectations
4. Exercises leadership qualities to effectively communicate ideas and make decisions.
5. Negotiates resources in order to accomplish objectives
6. Works well with all members of the class

C. *Information: Acquires and uses information*

1. Acquires and evaluates information
2. Organizes and maintains information
3. Interprets and communicates information

D. *Systems: Understands complex inter-relationships*

1. Understands and works well with social, organizational, and technological systems
2. Monitors and corrects performance of system during operation
3. Recommends modifications to system to improve performance

E. *Technology: Works with a variety of technologies*

1. Chooses relevant procedures, tools, and equipment
2. Applies appropriate procedures and techniques to accomplish tasks
3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks

1. ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*

- a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
- b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study

a. Demonstrates ability to objectively assess personal strengths and weaknesses
b. Demonstrates ability to set realistic short-term and long-term goals
c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
d. Demonstrates ability to identify potential pitfalls and take evasive actions
e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
g. Demonstrates maturity in taking responsibility for decisions

2. *Problem Solving: Recognizes problems and devises and implements plan of action*
    a. Demonstrates ability to detect problem through observation, inquiry, or directive
    b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    c. Demonstrates ability to generate alternatives or options for problem solution
    d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    e. Demonstrates ability to initiate and effect solution
    f. Demonstrates ability to take responsibility for outcomes
    g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. *Seeing Things In the Mind's Eye: Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
    b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
    c. Demonstrates ability to visually discriminate in gross and fine imagery
    d. Demonstrates ability to visualize abstractly

- f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
- g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines

4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
    - a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
    - b. Demonstrates ability to hear, comprehend, and appropriately follow directions
    - c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
    - d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
    - e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
    - f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed
5. *Speaking: Organizes ideas and communicates orally*
    - a. Demonstrates appropriate listening and speaking skills in personal conversations
    - b. Demonstrates ability to choose and organize appropriate words to effectively communicate
    - c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
    - d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
    - e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
    - f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
    - g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. *Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*

   - c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
   - d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
   - e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials
2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   - a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
   - b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
   - c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
   - d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
   - e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments
3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   - a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
   - b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
   - c. Demonstrates ability to understand and perform multi-step computations
   - d. Demonstrates ability to read, interpret, and use standard measuring devices
   - e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively

- e. Demonstrates ability to apply visual imagery to applied tasks

4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    - a. Demonstrates mastery of basic reading, math, and language skills through application
    - b. Demonstrates ability to translate abstract theory into practical application
    - c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
    - d. Demonstrates knowledge of good study skills and learning habits
5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    - a. Demonstrates use of simple logic
    - b. Demonstrates ability to distinguish relationships
    - c. Demonstrates ability to determine and isolate factors in relationships
    - d. Demonstrates and applies knowledge through practice
    - e. Recognizes that attitudes, skills, and practice are essential to productivity
    - f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
    - a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
    - b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
    - c. Demonstrates ability to focus on task at hand and work to completion
    - d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
    - e. Demonstrates maturity to take responsibility for actions
    - f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
    a. Presents a positive attitude toward tasks
    b. Demonstrates ability to separate work and personal behaviors
    c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
    d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
    e. Demonstrates ability to accept and use constructive criticism
    f. Accepts positive reinforcement in an appropriate manner
3. ***Sociability:** Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. Demonstrates appropriate and acceptable social behaviors in interactions
    b. Demonstrates ability to work cooperatively in individual, team, or group situations
    c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
    d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. Accepts personal strengths and weaknesses and uses the same for positive advancement
    b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
    c. Demonstrates ability to formulate and follow personal schedules
    d. Demonstrates ability to wisely use classroom time
    e. Demonstrates use of good study habits and skills
    f. Demonstrates maturity to take responsibility for own actions
5. *Integrity/Honesty: Chooses ethical courses of action*
    a. Knows and demonstrates ability to distinguish between positive and negative behaviors
    b. Demonstrates honesty and integrity in working with peers and supervisors
    c. Takes full responsibility for personal actions

d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable

e. Demonstrates positive work and social ethics in undertakings

CNS 2060

MASTER PROGRAM

Application Software

COURSE SYLLABUS

Total lecture hours: 12 **Total lab hours: 48** **Credit hours: 3**

COURSE DESCRIPTION:

Includes introductory concepts combined with an emphasis on the more predominate computer software including, but not limited to DOS, word processing, electronic spreadsheets, and databases; thus providing non-majors with computer literacy and hands-on experience.

PREREQUISITES: NONE

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Understand many of the most commonly used computer terms in use today;
2. Use basic DOS commands;
3. Use Microsoft's Windows graphical operation system;
4. Use Word 6.0 for Windows wordprocessor;
5. Use Excel 5.0 for Windows electronic spreadsheet; and,
6. Use Access 2.0 for Windows database software.

REQUIRED COURSE MATERIALS:

Textbook: *Microsoft Office Professional for Windows (Illustrated)*; by Halvorson, Swanson, Reding, Beskeen, and Johnson. Latest edition.

Lab Manual: None

Supplies/Quantity Required:

2	-	High density disks (3 ½")
6	-	Scantron test forms

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Laboratory: Laboratory will be hands-on application of computer software.

Method of Evaluation: A student' grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the computer skills as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments including writing assignments;
5. Contribute to class discussions; and,
6. Maintain attendance per current policy.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
DOS Commands	2
Review & Test - DOS Commands	1
Microsoft Windows 3.1	2
a. Getting started with Windows 3.1	
b. Creating and managing files	
Review & Test - Microsoft Windows 3.1	1
Microsoft Word 6.0	1
a. Getting started with Microsoft Word 6.0	
b. Creating and editing a document	
c. Formatting a document	
d. Arranging text and graphics	
Review & Test - Microsoft Word 6.0	1
Microsoft Excel 5.0	1
a. Getting started with Microsoft Excel 5.0	
b. Creating a worksheet	
c. Modifying a worksheet	
d. Working with charts	
e. Integrating Word and Excel	
Review & Test - Microsoft Excel 5.0	1
Microsoft Access 2.0	1
a. Getting started with Microsoft Access 2.0	
b. Creating a database	
c. Manipulating data	
d. Creating forms and reports	
Review & Test - Access 2.0 for Windows	1
Total Lecture Hours	**12**

LAB OUTLINE:

Lab Topics	**Contact Hrs.**
Work with DOS Tutor (Sections 2, 4, 5, 6, and 7)	12
Microsoft Windows 3.1 (Units 1 and 2)	10
Microsoft Word 6.0 (Units 1, 2, 3, and 4)	10
Microsoft Excel 5.0 (Units 1, 2, 3, and 4)	8
Microsoft Access 2.0 (Units 1, 2, 3, and 4)	8
Total Lab Hours	48

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
  A. *Resources: Identifies, organizes, plans, and allocates resources*
    1. Allocates time to complete assigned tasks on schedule
    2. Determines and allocates required materials and resources for meeting objectives
    3. Evaluates skills, performance, and quality of work and provides feedback
  B. *Interpersonal: Works with others*
    1. Participates as a member of the team, contributing to group effort
    2. Provides individual assistance/direction to peers as requested
    3. Determines and meets expectations
    4. Exercises leadership qualities to effectively communicate ideas and make decisions.
    5. Negotiates resources in order to accomplish objectives
    6. Works well with all members of the class
  C. *Information: Acquires and uses information*
    1. Acquires and evaluates information
    2. Organizes and maintains information

    3. Interprets and communicates information

D. Systems: Understands complex inter-relationships
    1. Understands and works well with social, organizational, and technological systems
    2. Monitors and corrects performance of system during operation
    3. Recommends modifications to system to improve performance

E. Technology: Works with a variety of technologies
    1. Chooses relevant procedures, tools, and equipment
    2. Applies appropriate procedures and techniques to accomplish tasks
    3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

A. Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks

*1. **Reading:** Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
    a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
    b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
    c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
    d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
    e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

*2. **Writing:** Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
    a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning

b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
    b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
    c. Demonstrates ability to understand and perform multi-step computations
    d. Demonstrates ability to read, interpret, and use standard measuring devices
    e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
    f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
    g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines
4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
    a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
    b. Demonstrates ability to hear, comprehend, and appropriately follow directions
    c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction

d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately

e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds

f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed

5. *Speaking: Organizes ideas and communicates orally*

a. Demonstrates appropriate listening and speaking skills in personal conversations

b. Demonstrates ability to choose and organize appropriate words to effectively communicate

c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation

d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes

e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups

f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations

g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*

a. Demonstrates ability to objectively assess personal strengths and weaknesses

b. Demonstrates ability to set realistic short-term and long-term goals

c. Demonstrates ability to recognize and distinguish between positive and negative alternatives

d. Demonstrates ability to identify potential pitfalls and take evasive actions

e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response

f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives

g. Demonstrates maturity in taking responsibility for decisions

2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    - a. Demonstrates ability to detect problem through observation, inquiry, or directive
    - b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    - c. Demonstrates ability to generate alternatives or options for problem solution
    - d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    - e. Demonstrates ability to initiate and effect solution
    - f. Demonstrates ability to take responsibility for outcomes
    - g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    - a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
    - b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
    - c. Demonstrates ability to visually discriminate in gross and fine imagery
    - d. Demonstrates ability to visualize abstractly
    - e. Demonstrates ability to apply visual imagery to applied tasks
4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    - a. Demonstrates mastery of basic reading, math, and language skills through application
    - b. Demonstrates ability to translate abstract theory into practical application
    - c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
    - d. Demonstrates knowledge of good study skills and learning habits
5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    - a. Demonstrates use of simple logic
    - b. Demonstrates ability to distinguish relationships

- c. Demonstrates ability to determine and isolate factors in relationships
- d. Demonstrates and applies knowledge through practice
- e. Recognizes that attitudes, skills, and practice are essential to productivity
- f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
    - a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
    - b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
    - c. Demonstrates ability to focus on task at hand and work to completion
    - d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
    - e. Demonstrates maturity to take responsibility for actions
    - f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner
2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
    - a. Presents a positive attitude toward tasks
    - b. Demonstrates ability to separate work and personal behaviors
    - c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
    - d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
    - e. Demonstrates ability to accept and use constructive criticism
    - f. Accepts positive reinforcement in an appropriate manner
3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    - a. Demonstrates appropriate and acceptable social behaviors in interactions
    - b. Demonstrates ability to work cooperatively in individual, team, or group situations

   - c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
   - d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   - a. Accepts personal strengths and weaknesses and uses the same for positive advancement
   - b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   - c. Demonstrates ability to formulate and follow personal schedules
   - d. Demonstrates ability to wisely use classroom time
   - e. Demonstrates use of good study habits and skills
   - f. Demonstrates maturity to take responsibility for own actions
5. *Integrity/Honesty: Chooses ethical courses of action*
   - a. Knows and demonstrates ability to distinguish between positive and negative behaviors
   - b. Demonstrates honesty and integrity in working with peers and supervisors
   - c. Takes full responsibility for personal actions
   - d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
   - e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
   MFG-I1 through MFG-I3.

MASTER Curriculum
Manufacturing Technology
(Associate of Applied Science Degree Program)

First Quarter*		LEC	LAB	CR
PSYC 1100	College Success Skills	1	0	1
MFG 100	Machine Tool Practices I	3	9	6
DDT 104	Drafting Principles	2	4	3
MATH 1314	College Algebra	4	0	3
ENGL 1301	Composition I	4	0	3
		14	13	16
Second Quarter*				
MFG 200	Machine Tool Practices II	3	9	6
ENGL 134	Interpersonal Communication	4	0	3
MATH 1316	Plane Trigonometry	4	0	3
CNS 2060	Application Software	1	4	3
		12	13	15
Third Quarter*				
MFG 112	Engineering Materials	2	3	3
OSH 216	Safety and Accident Prevention	2	3	3
PHY 114	Fluid Power I	3	3	4
EST 120	Electrical Applications	3	3	4
WLT 105	Survey of Welding Processes & Applications	3	3	4
		13	15	18
Fourth Quarter*				
MFG 205	CNC Machine Programming	3	3	4
MFG 206	Statics	3	3	4
MFG 301	Manufacturing Processes	3	3	4
DDT 128	Introduction to Computer Drafting	1	4	2
PSYC 2301	General Psychology	4	0	3
		14	13	17
FIFTH QUARTER*				
MFG 302	CAD/CAM I	3	3	4
MFG 216	Tool Design I	2	6	4
MFG 312	Strength of Materials	3	3	4
PHYS 1310	Fundamentals of Physics	4	0	3
	Free Elective	2	0	2
		14	12	17
Sixth Quarter*				
MFG 318	CAD/CAM II	3	3	4
MFG 315	Computer Integrated Manufacturing	2	2	3
MFG 324	Quality Assurance & Statistical Process Control	2	3	3
MFG 322	Engineering Technology Project	4	6	6
		11	14	16
	Program Totals	78	80	99

*** Each quarter is 12 weeks in length**

MFG 112

MASTER PROGRAM

Engineering Materials

COURSE SYLLABUS

Total lecture hours: 24 **Total lab hours: 36** **Credit hours: 3**

COURSE DESCRIPTION:

A study of metallic and nonmetallic materials used in design, including properties, characteristics, and methods of conducting common tests and interpreting data.

PREREQUISITES:

Machine Tool Practices I;
Machine Tool Practices II;
College Algebra

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. List the various steps, basic materials, and principles involved in making pig iron;
2. Identify various steel-making processes;
3. Explain several processes used in producing nonferrous metals;
4. Describe how steel is formed into various shapes and products;
5. List the advantages of some processes over others for a given product;
6. Identify different types of ferrous metals by various means of shop testing;
7. Select several commercial shafting alloys with various surface finishes;
8. Classify some nonferrous metals by a numerical system and identify others by testing methods;
9. List the general appearance and use of the various nonferrous metals;
10. Correctly define and describe the mechanical and physical properties of metals;
11. Describe the various testing machines and their uses, including the formulas and calculations needed;
12. Prepare specimens for the tensile tester and make tests and evaluations;
13. Prepare specimens for the Izod–Charpy tester and make tests and evaluations;
14. Conduct an experiment to demonstrate differences in thermal conductivity between two metals;
15. Perform an experiment that demonstrates the scaling characteristics of mild steel and stainless steel;

16. Make a Rockwell test on three specimens using the correct penetrator, major and minor loads, and scale;
17. Make a Rockwell superficial test on two specimens using the correct penetrator, major and minor loads, and scales;
18. Make a Brinell test on three specimens, read the impression with a Brinell microscope and determine the hardness number from a table;
19. Describe the various phases of crystalline structures of metals;
20. Describe the various aspects of solid solutions;
21. Conduct a Metcalf experiment and determine the approximate grain size in steel samples;
22. Prepare metal specimens for microscopic study by polishing and etching;
23. Demonstrate your understanding of phase diagrams by recognizing their parts;
24. Establish relative carbon content by microscopic evaluation;
25. Identify various cast iron compositions by microscopic examination;
26. Correctly harden a piece of tool steel and evaluate your work;
27. Correctly temper the hardened piece of tool steel and evaluate your work;
28. Explain the principles of an differences among the various kinds of annealing processes;
29. Test various steels with annealing, normalizing, and stress-relieving heat treatments in order to determine their effect on machinability and welding;
30. Determine the hardenability of steels and their quenching rates by using information gained from the I–T diagrams;
31. Recognize certain micro structures of transformation products produced at various temperatures by the use of the metallurgical microscope;
32. Estimate the hardness of a quenched steel by using the I–T diagram and the microscope;
33. Explain the methods of determining and evaluating the depth of hardening (hardenability) of various steels;
34. Demonstrate and measure the hardenability of a shallow-hardening steel;
35. Demonstrate the use of a hardened and tempered specimen;
36. Describe the proper heat-treating procedures for most tool steels;
37. Correctly harden an SAE 4140 steel part;
38. Correctly draw temper the SAE 4140 steel to a predetermined hardness;
39. Explain the reasons underlying the processes of solution heat treatment and precipitation hardening in which hardening takes place; and,
40. Demonstrate the process of hardening a heat-treatable aluminum alloy.

REQUIRED COURSE MATERIALS:

Textbook: *Practical Metallurgy and Materials of Industry,* John Neely, Wiley Pub., Latest Edition

Lab Manual: NONE

Tools and Equipment/Quantity Required:

Safety Glasses	1
Scientific Calculator	1

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Laboratory: Laboratory will be hands–on activities.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments including writing assignments;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all shop rules and safety regulations as stated in the laboratory manual.

LECTURE OUTLINE:

Lecture Topic	Contact Hrs.
Extracting Metals from Ores	
The Manufacture of Steel Products	
Identification and Selection of Iron and Steels	
Identification on Nonferrous Metals	
Identification and Selection of Nonmetallic Materials	
The Mechanical and Physical Properties of Materials	
Rockwell and Brinell Hardness Testers	
The Crystalline Structure of Materials	
Phase Diagrams and the Iron-Carbon Diagram	
Hardening and Tempering of Carbon Steels	
Annealing, Normalizing and Stress Relieving	
I–T Diagrams and Cooling Curves	
Harden ability of Steels and Tempered Martensite	
Heat-Treatment Equipment and Procedures	
Heat Treatment of Nonferrous Metals	
Total Lecture Hours	**24**

LAB OUTLINE:

Lab Topics	Contact Hrs.
Using Hardness Testers	6
a) Standard Rockwell Hardness Tester	
b) Superficial Rockwell Tester	
c) Automatic Rockwell Hardness Tester	
d) Shores Tester	
e) Brinell Tester	
f) Vickers Tester	
Microscopic Examination of Specimens	12
Determination of Critical Temperature of Steels	6
Tempering of Hardened Materials	4
Impact Testing	4
Determining the Harden ability of Steels	4
Total Lab Hours	**36**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
   - *A. Resources: Identifies, organizes, plans, and allocates resources*
      1. Allocates time to complete assigned tasks on schedule
      2. Determines and allocates required materials and resources for meeting objectives
      3. Evaluates skills, performance, and quality of work and provides feedback
   - *B. Interpersonal: Works with others*

    1. Participates as a member of the team, contributing to group effort
    2. Provides individual assistance/direction to peers as requested
    3. Determines and meets expectations
    4. Exercises leadership qualities to effectively communicate ideas and make decisions.
    5. Negotiates resources in order to accomplish objectives
    6. Works well with all members of the class

  C. *Information: Acquires and uses information*
    1. Acquires and evaluates information
    2. Organizes and maintains information
    3. Interprets and communicates information

  D. *Systems: Understands complex inter-relationships*
    1. Understands and works well with social, organizational, and technological systems
    2. Monitors and corrects performance of system during operation
    3. Recommends modifications to system to improve performance

  E. *Technology: Works with a variety of technologies*
    1. Chooses relevant procedures, tools, and equipment
    2. Applies appropriate procedures and techniques to accomplish tasks
    3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

  A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
    1. *Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
      a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
      b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
      c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
      d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner

   e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   - a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
   - b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
   - c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
   - d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
   - e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments
3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   - a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
   - b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
   - c. Demonstrates ability to understand and perform multi-step computations
   - d. Demonstrates ability to read, interpret, and use standard measuring devices
   - e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
   - f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
   - g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines
4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*

- a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
- b. Demonstrates ability to hear, comprehend, and appropriately follow directions
- c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
- d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
- e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
- f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed

5. *Speaking: Organizes ideas and communicates orally*
   - a. Demonstrates appropriate listening and speaking skills in personal conversations
   - b. Demonstrates ability to choose and organize appropriate words to effectively communicate
   - c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
   - d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
   - e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
   - f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
   - g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. *Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
   - a. Demonstrates ability to objectively assess personal strengths and weaknesses
   - b. Demonstrates ability to set realistic short-term and long-term goals
   - c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
   - d. Demonstrates ability to identify potential pitfalls and take evasive actions

    e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
    f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
    g. Demonstrates maturity in taking responsibility for decisions
2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    a. Demonstrates ability to detect problem through observation, inquiry, or directive
    b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    c. Demonstrates ability to generate alternatives or options for problem solution
    d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    e. Demonstrates ability to initiate and effect solution
    f. Demonstrates ability to take responsibility for outcomes
    g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
    b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
    c. Demonstrates ability to visually discriminate in gross and fine imagery
    d. Demonstrates ability to visualize abstractly
    e. Demonstrates ability to apply visual imagery to applied tasks
4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. Demonstrates mastery of basic reading, math, and language skills through application
    b. Demonstrates ability to translate abstract theory into practical application

        c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
        d. Demonstrates knowledge of good study skills and learning habits
    5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
        a. Demonstrates use of simple logic
        b. Demonstrates ability to distinguish relationships
        c. Demonstrates ability to determine and isolate factors in relationships
        d. Demonstrates and applies knowledge through practice
        e. Recognizes that attitudes, skills, and practice are essential to productivity
        f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty
    1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
        a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
        b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
        c. Demonstrates ability to focus on task at hand and work to completion
        d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
        e. Demonstrates maturity to take responsibility for actions
        f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner
    2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
        a. Presents a positive attitude toward tasks
        b. Demonstrates ability to separate work and personal behaviors
        c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
        d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors

  - e. Demonstrates ability to accept and use constructive criticism
  - f. Accepts positive reinforcement in an appropriate manner

3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   - a. Demonstrates appropriate and acceptable social behaviors in interactions
   - b. Demonstrates ability to work cooperatively in individual, team, or group situations
   - c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
   - d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   - a. Accepts personal strengths and weaknesses and uses the same for positive advancement
   - b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   - c. Demonstrates ability to formulate and follow personal schedules
   - d. Demonstrates ability to wisely use classroom time
   - e. Demonstrates use of good study habits and skills
   - f. Demonstrates maturity to take responsibility for own actions
5. *Integrity/Honesty: Chooses ethical courses of action*
   - a. Knows and demonstrates ability to distinguish between positive and negative behaviors
   - b. Demonstrates honesty and integrity in working with peers and supervisors
   - c. Takes full responsibility for personal actions
   - d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
   - e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
    MFG-A1 through MFG-A5;
    MFG-B1 through MFG-B3;
    MFG-B6 through MFG-B7;
    MFG-C3;
    MFG-D1;
    MFG-D3 through MFG-D4; and,
    MFG-G1 through MFG-G3.
2. *Machinery's Handbook,* Industrial Press, Latest Edition
3. *Technology of Machine Tools,* McGraw Hill Publishers, Latest Edition

MFG 112
01/081997

OSH 216

MASTER PROGRAM

Safety and Accident Prevention

COURSE SYLLABUS

Total lecture hours: 24 **Total lab hours: 36** **Credit hours: 3**

COURSE DESCRIPTION:

Enables the student to recognize hazards and potential hazards which occur in the workplace and to take corrective action. The course may be directed toward a specific technology as required. Federal safety requirements under the OSHA law are emphasized. General supervisor safety training course for all technologies.

PREREQUISITES: NONE

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Explain all the elements of good communication as it relates to safety;
2. Apply several human relations concepts as a supervisor to ensure safety in the work place;
3. Discuss the importance of industrial hygiene and noise control;
4. Correctly fill out an accident investigation report and a safety inspection form;
5. Discuss and/or demonstrate the use of personal protective equipment;
6. Apply the principles of and discuss the benefits of machine safeguarding;
7. Explain and/or demonstrate the use and safe handling of hand and portable power tools;
8. Discuss safe electrical procedures;
9. Discuss the basic principles and causes of fire; and,
10. Explain the need for safety training of workers.

REQUIRED COURSE MATERIALS:

Textbook: *Supervisor's Safety Manual,* National Safety Council, Latest Edition

Lab Manual: NONE

Hand Tools/Quantity Required:

Notebook paper
Notebook

Pencils or pens

METHODS OF INSTRUCTION:

Lecture:	Didactic presentations will include lecture, demonstrations, and the following training materials and visual aids (OSH Film Library): "The Convincer" - 45 min. color slide "Safety and the Supervisor - 16 mm - color film "All About OSHA" - 16 mm - color film "Search for Safety" - 16 mm - color film "In Search of the Facts" - 16 mm - color film "Color of Danger" - 16 mm - color film "Six Ways to Lift" - 16 mm - color film "MGM Grand Hotel Fire" - 16 mm - color film
Laboratory:	Laboratory assignments will require students to recognize hazards and potential hazards which may occur in the workplace and to take corrective action.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Satisfactorily perform on written, oral, and practical examinations;
3. Explain all the elements of good communication as it relates to safety;
4. Apply several human relations concepts as a supervisor to ensure safety in the work place;
5. Discuss the importance of industrial hygiene and noise control;
6. Correctly fill out an accident investigation report and a safety inspection form;
7. Discuss and/or demonstrate the use of personal protective equipment;
8. Apply the principles of and discuss the benefits of machine safeguarding;
9. Explain and/or demonstrate the use and safe handling of hand and portable power tools;
10. Discuss safe electrical procedures;
11. Discuss the basic principles and causes of fire;
12. Explain the need for safety training of workers;
13. Satisfactorily perform on outside assignments including writing assignments;
14. Contribute to class discussions;
15. Maintain attendance per current policy; and,

16. Follow all shop rules and safety regulations as stated in the laboratory manual.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction	1
Course content and text	
Attendance and grading	
Testing procedures	
The origin of the safety movement	
The Williams-Steiger Act	
OSHAct applied to technology	
Safety Management	1
Definition of terms	
Areas of responsibility	
The "old" approach to safety performance	
A better approach to safety performance	
Summary of Key Points	
Communications	1
Elements of communication	
Methods of communication	
Effective listening	
Summary of key points	
Human Relations	1
Human relations concepts	
Leadership	
Coping with difficult problems	
Shift work and shift changes	
Stress management	
Alcohol and drug problems	
Employee assistance programs	
Summary of key points	
Employee Safety Training	1
Orientation training	
Job instruction training	
Other methods of instruction	
Job safety analysis	
Summary of key points	
Employee Improvement	1
Promoting safety among workers	
Off-the-job accident problems	
Summary of key points	
EXAM #1	1

Safety Inspections	1
Formal inspections	
Inspection planning and procedures	
Inspecting work practices	
Inspection reports	
Summary of key points	
Accident Investigation	1
Accident reporting	
Finding causes	
Emergency procedures	
Effective use of witnesses	
Accident investigation reports	
Summary of key points	
EXAM #2	1
Industrial Hygiene	1
Chemical stresses	
Physical stresses	
Ergonomic stresses	
Biological stresses	
Threshold limit values	
Standard Operating Procedures (SOP)	
Summary of key points	
EXAM #3	1
Personal Protective Equipment	1
Controlling hazards	
Head protection	
Face protection	
Eye protection	
Ear protection	
Respiratory protection	
Body protection	
Protecting extremities	
Summary of key points	
EXAM #4	1
Ergonomics	1
What are ergonomic problems?	
Understanding ergonomics	
Materials movement	
Work space and body characteristics	
Hand work and use of tools	
Whole-body vibration	
Video display terminals	
Lighting, noise, and heat	
Summary of key points	
EXAM #5	1

Machine Safeguarding 1

- Principles of guarding
- Safeguard design
- Safeguarding mechanisms
- Automation
- Maintenance of safeguards
- Summary of key points

Hand Tools and Portable Power Tools 1

- Safe work practices
- Use of hand tools
- Portable power tools
- Supervisory considerations
- Maintenance and repair
- Summary of key points

Materials Handling and Storage 1

- Materials handling problems
- Manual handling methods
- Materials handling equipment
- Ropes, chains, and slings
- Materials storage
- Summary of key points

EXAM #6 1

Electrical Safety 1

- Myths and misconception about electricity
- Electrical fundamentals review
- Branch circuits and grounding concepts
- Plug and cord connected equipment and extension cords
- Branch circuit and equipment testing methods
- Ground-fault circuit interrupters
- Hazardous locations
- Electrical standards most often violated
- Inspection guidelines and checklist
- Safeguards for portable home electrical appliances
- Safety program policy and procedures
- Electrical distribution system review
- Summary of key points

Fire Safety 1

- Basic principles
- Causes of fire
- Other hazardous materials
- Effective housekeeping for fire safety
- Fire prevention inspections
- Alarms, equipment, and evacuation

Fire protection education	
Protective insurance requirements	
Summary of key points	
EXAM #7	1
Total Lecture Hours	**24**

LAB OUTLINE:

Lab Topics	**Contact Hrs.**
Students will research each chapter of the *Supervisor's Safety Manual* and answer questions which cover the main points of the chapter	16
Students will demonstrate the six steps in proper lifting	4
Students will demonstrate the proper use of powered hand tools	6
Students will demonstrate the use of different types of fire extinguishers	6
Students will explain the importance of inspecting electrical extension cords, plugs and cord-connected equipment	4
Total Lab Hours	**36**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

A. ***Resources:** Identifies, organizes, plans, and allocates resources*
   1. Allocates time to complete assigned tasks on schedule
   2. Determines and allocates required materials and resources for meeting objectives

    3. Evaluates skills, performance, and quality of work and provides feedback
B. *Interpersonal: Works with others*
    1. Participates as a member of the team, contributing to group effort
    2. Provides individual assistance/direction to peers as requested
    3. Determines and meets expectations
    4. Exercises leadership qualities to effectively communicate ideas and make decisions.
    5. Negotiates resources in order to accomplish objectives
    6. Works well with all members of the class
C. *Information: Acquires and uses information*
    1. Acquires and evaluates information
    2. Organizes and maintains information
    3. Interprets and communicates information
D. *Systems: Understands complex inter-relationships*
    1. Understands and works well with social, organizational, and technological systems
    2. Monitors and corrects performance of system during operation
    3. Recommends modifications to system to improve performance
E. *Technology: Works with a variety of technologies*
    1. Chooses relevant procedures, tools, and equipment
    2. Applies appropriate procedures and techniques to accomplish tasks
    3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS
A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
    1. ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
        a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
        b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
        c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)

   - d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
   - e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. ***Writing:** Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   - a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
   - b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
   - c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
   - d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
   - e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. ***Arithmetic/Mathematics:** Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   - a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
   - b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
   - c. Demonstrates ability to understand and perform multi-step computations
   - d. Demonstrates ability to read, interpret, and use standard measuring devices
   - e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
   - f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance

        g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines

    4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
        a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
        b. Demonstrates ability to hear, comprehend, and appropriately follow directions
        c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
        d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
        e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
        f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed
    5. ***Speaking*****:** *Organizes ideas and communicates orally*
        a. Demonstrates appropriate listening and speaking skills in personal conversations
        b. Demonstrates ability to choose and organize appropriate words to effectively communicate
        c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
        d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
        e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
        f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
        g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons
    1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
        a. Demonstrates ability to objectively assess personal strengths and weaknesses

   b. **Demonstrates ability to set realistic short-term and long-term goals**
   c. **Demonstrates ability to recognize and distinguish between positive and negative alternatives**
   d. **Demonstrates ability to identify potential pitfalls and take evasive actions**
   e. **Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response**
   f. **Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives**
   g. **Demonstrates maturity in taking responsibility for decisions**

2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
   a. **Demonstrates ability to detect problem through observation, inquiry, or directive**
   b. **Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation**
   c. **Demonstrates ability to generate alternatives or options for problem solution**
   d. **Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution**
   e. **Demonstrates ability to initiate and effect solution**
   f. **Demonstrates ability to take responsibility for outcomes**
   g. **Demonstrates ability to effectively problem solve in individual, team, or group situations**

3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
   a. **Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery**
   b. **Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues**
   c. **Demonstrates ability to visually discriminate in gross and fine imagery**
   d. **Demonstrates ability to visualize abstractly**
   e. **Demonstrates ability to apply visual imagery to applied tasks**

4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. **Demonstrates mastery of basic reading, math, and language skills through application**
    b. **Demonstrates ability to translate abstract theory into practical application**
    c. **Demonstrates ability to incorporate and generalize new learning into a sequential learning process**
    d. **Demonstrates knowledge of good study skills and learning habits**

5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. **Demonstrates use of simple logic**
    b. **Demonstrates ability to distinguish relationships**
    c. **Demonstrates ability to determine and isolate factors in relationships**
    d. **Demonstrates and applies knowledge through practice**
    e. **Recognizes that attitudes, skills, and practice are essential to productivity**
    f. **Demonstrates ability to discriminate between positive and negative, and act accordingly**

C. **Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty**

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
    a. **Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals**
    b. **Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner**
    c. **Demonstrates ability to focus on task at hand and work to completion**
    d. **Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time**
    e. **Demonstrates maturity to take responsibility for actions**
    f. **Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner**

2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
    a. **Presents a positive attitude toward tasks**

   b. Demonstrates ability to separate work and personal behaviors
   c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
   d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
   e. Demonstrates ability to accept and use constructive criticism
   f. Accepts positive reinforcement in an appropriate manner
3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   a. Demonstrates appropriate and acceptable social behaviors in interactions
   b. Demonstrates ability to work cooperatively in individual, team, or group situations
   c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
   d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   a. Accepts personal strengths and weaknesses and uses the same for positive advancement
   b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   c. Demonstrates ability to formulate and follow personal schedules
   d. Demonstrates ability to wisely use classroom time
   e. Demonstrates use of good study habits and skills
   f. Demonstrates maturity to take responsibility for own actions
5. ***Integrity/Honesty:*** *Chooses ethical courses of action*
   a. Knows and demonstrates ability to distinguish between positive and negative behaviors
   b. Demonstrates honesty and integrity in working with peers and supervisors
   c. Takes full responsibility for personal actions
   d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
   e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
   MFG-A1 through MFG-A7.

OSH 216
01/051897

PHY 114

MASTER PROGRAM

Fluid Power I

COURSE SYLLABUS

Total lecture hours: 36 **Total lab hours: 36** **Credit hours: 4**

COURSE DESCRIPTION:

A study of hydraulic system components, fluid power theory, problem solving, and troubleshooting techniques.

PREREQUISITES: **Mathematics for Industrial Technicians, Basic Algebraic Concepts, or equivalent**

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Identify and describe the major components of a hydraulic system;
2. Identify the ANSI standard symbols for major components;
3. Use Pascal's Law;
4. Understand the basic principles of fluidic pressure and flow;
5. Identify types, properties, and hazards of hydraulic fluids;
6. Understand the uses of the several components of a typical hydraulic system;
7. Troubleshoot a basic hydraulic system; and
8. Understand and use mathematical formulae for hydraulic systems, including horsepower, work, and power.

REQUIRED COURSE MATERIALS:

Textbook: *Industrial Hydraulic Technology,* Parker Hannifin Corp., Latest Edition

Lab Manual: NONE

Supplies Required:

Electronic Pocket Calculator
    (Texas Instruments Model No. TI-35 or equivalent)
Ruler-plastic, 12-inch, graduated in inches and centimeters
Notebook
Ballpoint pen

#2 Pencil (6)

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Laboratory: Laboratory will be hands–on activities.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments including writing assignments;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all shop rules and safety regulations as stated in the laboratory manual.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction	1
A. Historical background	
B. Advantages and application of hydraulic power	
1) List five advantages of hydraulic power	
2) List five examples of the application of hydraulic power	
C. Overview of a typical hydraulic system	
1) Identify by name and describe the function of the major components of a basic hydraulic system	
2) Sketch or identify the ANSI standard symbol for each major component	
Basic Principles of Hydraulics	8
A. Pressure and force relationships	
1) State or describe the consequences of Pascal's law	
2) Knowing the basic mathematical relationship of pressure, force, and area, solve for any *one*	

given the other *two*

B. Principles and Concepts of Fluid Pressure and Flow
  1) Given the density or specific gravity of a fluid, calculate the pressure head for a given fluid height
  2) State Bernoulli's Theory in terms of velocity and pressure
  3) Using the Continuity Equation, solve for hydraulic line size given the flow rate and velocity parameters; determine cylinder extension speed (or time) given flow rate and cylinder size; determine flow velocity in various sized lines given flow rate
  4) State the results of Torricelli's Theories in terms of pressure head and velocity
  5) Use the Reynolds Number to determine laminar or turbulent flow
  6) Given the movement of a load in a given time interval, calculate work, power, and horsepower
  7) Analyze a hydraulic system to determine its performance given the specifications of the pump and various actuators (cylinders, hydraulic motors, rotary actuators)

Hydraulic Fluids 3

A. Types, properties, and safety
  1) Name three types of hydraulic fluid
  2) List two methods of measuring fluid viscosity
  3) List four desirable characteristics of a hydraulic fluid
  4) Given a hypothetical hydraulic system configuration, identify the safety hazards and means of correction

B. Fluid storage and conditioning
  1) List five features of a well-designed hydraulic reservoir
  2) Name two types of heat exchanger
  3) Name two *basic types* of filter elements
  4) Explain what is meant by the micron rating of filters
  5) List three benefits derived from proper conditioning of hydraulic fluid

Power, Distribution and Sealing Devices 2

A. Lines, hoses and fittings

    1) Given the pressures and flow rates of a system, select the correct tubing size for a properly designed hydraulic system
    2) Show actual or illustrated hose installations, identify improper installation and recommend an acceptable configuration
    3) Show actual or illustrated tubing connectors, properly identify them within the two main classifications

B. Pressure, velocity, and safety factors
    1) Using Barlow's Formula, or a proper reference chart, determine the allowable maximum pressure of a given conductor
    2) Determine working pressure of a system given the safety factor
    3) Using Darcy's Formula, calculate the pressure drop of a given length of conductor
    4) Given the Reynold's Number, determine whether the flow is laminar or turbulent
    5) Using a nomograph, determine the flow rate, conductor size, or flow velocity given any two parameters
    6) Determine hydraulic pump inlet and discharge line size given the flow rate, using the Continuity Equation and accepted industrial velocity parameters

C. Sealing devices
    1) List three conditions affecting the selection of sealing devices
    2) Name the three general categories of sealing materials

Pumps 3

A. Types and operation
    1) Name the two general classifications of pumps
    2) List the design features, main uses, and describe the operation of each of the two types of pumps
    3) Know why *positive displacement* pumps are preferred for fluid power systems

B. Theory and calculations
    1) Calculate the theoretical output flow and input torque of a positive displacement pump
    2) Determine *overall* pump efficiency
    3) Determine the *volumetric efficiency* of a pump

   4) Determine the *mechanical efficiency* of a pump
   5) Calculate the hydraulic horsepower output of a pump

C. Design and selection factors
   1) Name three types of positive displacement pumps; list the advantages/disadvantages of each
   2) Name two types of variable delivery pumps and describe their operation
   3) Using catalog or advertising data, evaluate various pumps for use in specific applications

Hydraulic Actuators 2

A. Linear actuators (cylinders)
   1) Name two of the most common *types* of cylinders
   2) Describe how cylinders are rated and sized
   3) Using an illustration or actual cylinder, name and identify the parts
   4) Given the size of a cylinder and the system flow rate, calculate the cylinder extension speed or extension time
   5) Given system flow and pressure, or load, stroke, and extension time, calculate the power output of a cylinder

B. Rotary actuators and motors
   1) Name the two general *types* of hydraulic motors
   2) Name the three principle elements of motor *ratings*
   3) Given displacement and flow rate, calculate motor speed (rpm)
   4) Given the torque and rpm of a motor, calculate the hydraulic horsepower

Hydraulic Controls 8

A. Control of hydraulic power
   1) Name the three primary ways of controlling pressurized hydraulic fluid
   2) Name five types of *pressure* control valves and describe their use and operation
   3) Name at least four types or designs of directional control valves and describe their use
   4) Describe the function of flow control valves and name three types or designs

B. Hydraulic circuits
   1) Describe the function of pressure controls for sequencing actuators, counterbalances or

braking applications, safety or relief operations, pressure reducing and unloading functions
    2) Explain the function and proper application of meter-in, meter-out, and bleed-off circuits
    3) Explain the function of a three-position directional control valve and name four common center designs
    4) Describe the use and limitations of a regenerative circuit
    5) Describe the difference between a hydrostatic *transmission* and a hydrostatic *drive* and give three applications

Hydraulic System Troubleshooting 2

A. Define component relationships
    1) Given a real or hypothetical hydraulic system, trace the flow through the entire system, state the purpose of each component, and describe the action or operation of each component at each control setting

B. Analyze pressure and flow
    1) Name the three common terms used when referring to pressure within a hydraulic system
    2) Describe the causes of each of the three kinds of system pressure
    3) Describe the effect of increased or decreased flow on actuator operation
    4) Describe the effect of increased or decreased pressure on actuator operation

C. Troubleshooting sequence
    1) Describe two ways of determining the problem with a malfunctioning hydraulic system
    2) Given the fault in a malfunctioning hydraulic system, describe the component relationships
    3) Make a list of possible causes for the malfunctioning of the given system
    4) Given the specifications of a hydraulic system, compare them to actual or hypothetical measurements
    5) Given a malfunctioning hydraulic system, following a logical troubleshooting sequence, trace the problem to its origin

Fluid Power System Maintenance and Safety 1

A. Maintenance

    1) List three general requirements for a good maintenance program
    2) In addition to a proper set of mechanics tools and gauges, list two other factors which are considered "tools" for good maintenance
    3) List at least three types of records used to insure proper preventive maintenance

B. Safety
    1) List five safety rules for the *operator* of fluid power machinery
    2) List five safety rules for the fluid power *mechanic*

Major Exams and Critiques	6
Total Lecture Hours	**36**

LAB OUTLINE:

Lab Topics	**Contact Hrs.**
The Fundamental Hydraulic Circuit This exercise establishes a common base for discussion of hydraulic systems by providing the student the opportunity to: A. Identify hydraulic components B. Assemble components into a hydraulic circuit C. Adjust valve settings D. Operate a basic circuit E. Test circuit operation	3
Basic Physical Laws Pressure and flow relationships are introduced and demonstrated under flow and non-flow (Pascal's Law) conditions	3
Pressure and Force Pressure and force relationships are illustrated by: A. Demonstration of pressure, force, area relationships B. Causes of pressure, units of measurement, measuring instruments C. Concept of the "hydraulic lever D. Cylinder load and working pressure relationships	3
Flow Rate and Velocity Relationships between flow rate and actuator speed, creation of flow in the system, calculation and measurement of flow, actuator speed, and cylinder extension times are examined and demonstrated	3
Work, Power and Horsepower	3

Definitions of work and power, relationships between pressure and flow to produce power, demonstration and calculations using formulas, and concepts of efficiency are examined

Properties of Hydraulic Fluids and Fluid Storage Conditioning 3

A combined lab exercise of activity 6 and 9 to illustrate:

A. Effect of temperature change on viscosity
B. Relationship of viscosity and resistance to flow through hydraulic lines, valves, and fitting
C. Characteristics of a well designed reservoir
D. Importance of proper fluid conditioning

Fluid Power Symbols 3

The introduction of graphic symbols used in industrial diagrams. (Previous introductory labs used pictorial symbols as a training aid.) Basic symbols for components are studied and practiced by interpreting and sketching simple hydraulic circuits

Hydraulic Pumps 3

The concept of pumps displacement and its relationship to output flow, volumetric efficiency, and the effects of temperature are demonstrated

Fluid Transmission and Introduction to Control Valves 3

A combined lab of Activity 10 and 11 to illustrate:

A. Hydraulic conductors, terminology, design features, sizing, and selection are demonstrated
B. Pressure, flow, and directional controls are introduced and demonstrated

Pressure Control Valves 3

Design features and function of pressure controls are discussed. Definition of terms and testing of a pilot-operated relief valve, to include plotting of test results, demonstrates valve operation

Directional Control Valves 3

Design features, terminology, and valve configurations are demonstrated and discussed

Flow Control Valves 3

Valve ratings and concepts of compensation are discussed and pressure compensation is demonstrated in the lab exercise

Total Lab Hours 36

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
   - *A. Resources: Identifies, organizes, plans, and allocates resources*
     1. Allocates time to complete assigned tasks on schedule
     2. Determines and allocates required materials and resources for meeting objectives
     3. Evaluates skills, performance, and quality of work and provides feedback
   - *B. Interpersonal: Works with others*
     1. Participates as a member of the team, contributing to group effort
     2. Provides individual assistance/direction to peers as requested
     3. Determines and meets expectations
     4. Exercises leadership qualities to effectively communicate ideas and make decisions.
     5. Negotiates resources in order to accomplish objectives
     6. Works well with all members of the class
   - *C. Information: Acquires and uses information*
     1. Acquires and evaluates information
     2. Organizes and maintains information
     3. Interprets and communicates information
   - *D. Systems: Understands complex inter-relationships*
     1. Understands and works well with social, organizational, and technological systems
     2. Monitors and corrects performance of system during operation
     3. Recommends modifications to system to improve performance
   - *E. Technology: Works with a variety of technologies*
     1. Chooses relevant procedures, tools, and equipment
     2. Applies appropriate procedures and techniques to accomplish tasks

3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS
  A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
    1. ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
      a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
      b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
      c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
      d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
      e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials
    2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
      a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
      b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
      c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
      d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
      e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
    b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
    c. Demonstrates ability to understand and perform multi-step computations
    d. Demonstrates ability to read, interpret, and use standard measuring devices
    e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
    f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
    g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines
4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
    a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
    b. Demonstrates ability to hear, comprehend, and appropriately follow directions
    c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
    d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
    e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
    f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed
5. ***Speaking*:** *Organizes ideas and communicates orally*
    a. Demonstrates appropriate listening and speaking skills in personal conversations
    b. Demonstrates ability to choose and organize appropriate words to effectively communicate

- c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
- d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
- e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
- f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
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B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    - a. Demonstrates ability to objectively assess personal strengths and weaknesses
    - b. Demonstrates ability to set realistic short-term and long-term goals
    - c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
    - d. Demonstrates ability to identify potential pitfalls and take evasive actions
    - e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
    - f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
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2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    - a. Demonstrates ability to detect problem through observation, inquiry, or directive
    - b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    - c. Demonstrates ability to generate alternatives or options for problem solution
    - d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution

   - e. Demonstrates ability to initiate and effect solution
   - f. Demonstrates ability to take responsibility for outcomes
   - g. Demonstrates ability to effectively problem solve in individual, team, or group situations
- *3.* ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
   - a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
   - b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
   - c. Demonstrates ability to visually discriminate in gross and fine imagery
   - d. Demonstrates ability to visualize abstractly
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   - a. Demonstrates mastery of basic reading, math, and language skills through application
   - b. Demonstrates ability to translate abstract theory into practical application
   - c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
   - d. Demonstrates knowledge of good study skills and learning habits
- *5.* ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   - a. Demonstrates use of simple logic
   - b. Demonstrates ability to distinguish relationships
   - c. Demonstrates ability to determine and isolate factors in relationships
   - d. Demonstrates and applies knowledge through practice
   - e. Recognizes that attitudes, skills, and practice are essential to productivity
   - f. Demonstrates ability to discriminate between positive and negative, and act accordingly

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- *1.* ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*

- a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
- b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
- c. Demonstrates ability to focus on task at hand and work to completion
- d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
- e. Demonstrates maturity to take responsibility for actions
- f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
    - a. Presents a positive attitude toward tasks
    - b. Demonstrates ability to separate work and personal behaviors
    - c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
    - d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
    - e. Demonstrates ability to accept and use constructive criticism
    - f. Accepts positive reinforcement in an appropriate manner
3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    - a. Demonstrates appropriate and acceptable social behaviors in interactions
    - b. Demonstrates ability to work cooperatively in individual, team, or group situations
    - c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
    - d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    - a. Accepts personal strengths and weaknesses and uses the same for positive advancement

- b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
- c. Demonstrates ability to formulate and follow personal schedules
- d. Demonstrates ability to wisely use classroom time
- e. Demonstrates use of good study habits and skills
- f. Demonstrates maturity to take responsibility for own actions

5. ***Integrity/Honesty:*** *Chooses ethical courses of action*
    - a. Knows and demonstrates ability to distinguish between positive and negative behaviors
    - b. Demonstrates honesty and integrity in working with peers and supervisors
    - c. Takes full responsibility for personal actions
    - d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
    - e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
    MFG-A1 through MFG-A4;
    MFG-A6;
    MFG-B1 through MFG-B3;
    MFG-B13; and,
    MFG-L1 through MFG L2.

MASTER PROGRAM

Electrical Applications

COURSE SYLLABUS

Total lecture hours: 36 **Total lab hours: 36** **Credit hours: 4**

COURSE DESCRIPTION:

A survey course designed to present basic concepts in DC and AC circuits, fundamental motor design and applications, and basic motor controls.

PREREQUISITES: NONE

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Follow safe practices in using electricity;
2. Analyze atomic structure and the proportionalism that makes an atom a good conductor;
3. Analyze electrical quantities in circuits, including voltage, current, resistance, and power;
4. Analyze series and parallel DC circuits using Ohm's law and Kirchoff's voltage and current laws;
5. Analyze complex DC circuits using Ohm's law and Kirchoff's voltage and current laws; and,
6. Relate the principles of magnetism and inductance to electrical circuits.

REQUIRED COURSE MATERIALS:

Textbook: *Delmar's Standard Textbook of Electricity*, Stephen L. Herman, Delmar Publishers, Inc., Latest Edition.

Lab Manual: NONE

Hand Tools/Quantity Required:

- Notebook paper (50 sheets)
- Binder
- Scientific calculator
- Test leads with alligator clips (12 minimum)
- Screwdriver - 6 inch long, 3/16 inch straight blade

Screwdriver - #2 Phillips
Safety glasses

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Laboratory: Laboratory will include presentation of basic concepts in DC and AC circuits, including analyzing, calculating, and measuring DC and AC voltage, current, and resistance, as well as fundamental motor design, applications and controls.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Satisfactorily perform on written, oral, and practical examinations;
3. Follow safe practices in using electricity;
4. Analyze atomic structure and the proportionalism that makes an atom a good conductor;
5. Analyze electrical quantities in circuits, including voltage, current, resistance, and power;
6. Analyze series and parallel DC circuits using Ohm's law and Kirchoff's voltage and current laws;
7. Analyze complex DC circuits using Ohm's law and Kirchoff's voltage and current laws;
8. Relate the principles of magnetism and inductance to electrical circuits;
9. Satisfactorily perform on outside assignments including writing assignments;
10. Contribute to class discussions;
11. Maintain attendance per current policy; and,
12. Follow all shop rules and safety regulations as stated in the laboratory manual.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to Electricity	4
Define atoms, protons, electrons, charge, voltage, current, resistance, power, electricity, etc.	
Decode the colors of a carbon resistor	
Apply Ohm's law	

Series Circuits 4

Define a series circuit

Apply Ohm's law and Kirchoff's voltage law to a series circuit

Evaluate a simple circuit to determine if it is a series circuit

Parallel Circuits 4

Define a parallel circuit

Apply Ohm's law and Kirchoff's law to a parallel circuit

Evaluate a simple circuit to determine if it is a parallel circuit

Complex DC Circuits 4

Analyze a circuit to establish a circuit arrangement

- What is series?
- What is parallel?

Apply series/parallel parameters to circuit

Apply Ohm's law and Kirchoff's current voltage law to the circuit

Magnetism and Inductance 4

Define magnetism and inductance

Relate the effects of magnetism and inductance to AC devices

Define impedance, inductive reactance and capacitive reactance

AC Circuits 4

Define alternating current

List examples of AC signals

Illustrate the generation of a sinewave

Define terms relating to AC signals

- Peak values
- RMS values
- Instantaneous values
- Frequency
- Period
- Cycle
- Hertz

Inductance and Capacitance 4

Define inductance and capacitance

Relate the effects of inductance and capacitance to AC circuits and motors

Relays 4

Define relay construction and the principle of operation

List the different types of relays

Transformers 4

Define transformer construction and the principle

of operation
List the different types of transformers

Total Lecture Hours 36

LAB OUTLINE:

Lab Topics	Contact Hrs.
Safety and Orientation	2
Review lab safety	
Demonstrate uses of analog volt-ohm-milliamp meter	
Resistance	3
Practice decoding color bands of a carbon resistor	
Demonstrate resistance measuring function of analog meter	
Measure carbon resistors	
Calculate percent error of resistor; coded value versus measured value	
Voltage	4
Demonstrate voltage measuring function of analog meter	
Measure voltage output of series-aiding, series-opposing, parallel and series-parallel battery groupings	
Compare the advantages and disadvantages of power supplies and battery sources	
Current	3
Demonstrate the current measuring function of an analog meter	
Measure current in a variety of simple circuits	
Power	3
Demonstrate the use of a wattmeter to measure power in a simple DC circuit	
Measure power in a circuit	
Confirm the validity of power formulas by measurements of power in a circuit	
Series Circuits	4
Build a simple series circuit	
Analyze a series circuit	
Parallel Circuits	4
Build a simple parallel circuit	
Confirm the four parameters that govern a parallel circuit	
Troubleshoot a parallel circuit	
Complex (Series/Parallel) Circuits	4
Build a complex circuit	
Analyze a complex circuit	
Magnetism	3

Analyze the properties of permanent magnets	
Observe and analyze the operation and properties of electromagnets	
Magnetic Induction	3
Analyze the properties of magnetic induction	
Observe magnetic induction in operation	
AC Signals	3
Observe AC signals of various wave shapes and frequencies on an oscilloscope	
Compare peak values on oscilloscope with RMS values of analog meter	
Measure voltage with analog volt-ohm-milliamp meter	—
Total Lab Hours	**36**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
   - A. *Resources: Identifies, organizes, plans, and allocates resources*
      1. Allocates time to complete assigned tasks on schedule
      2. Determines and allocates required materials and resources for meeting objectives
      3. Evaluates skills, performance, and quality of work and provides feedback
   - B. *Interpersonal: Works with others*
      1. Participates as a member of the team, contributing to group effort
      2. Provides individual assistance/direction to peers as requested
      3. Determines and meets expectations
      4. Exercises leadership qualities to effectively communicate ideas and make decisions.

   5. Negotiates resources in order to accomplish objectives
   6. Works well with all members of the class

C. *Information: Acquires and uses information*
   1. Acquires and evaluates information
   2. Organizes and maintains information
   3. Interprets and communicates information

D. *Systems: Understands complex inter-relationships*
   1. Understands and works well with social, organizational, and technological systems
   2. Monitors and corrects performance of system during operation
   3. Recommends modifications to system to improve performance

E. *Technology: Works with a variety of technologies*
   1. Chooses relevant procedures, tools, and equipment
   2. Applies appropriate procedures and techniques to accomplish tasks
   3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
   1. ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
      a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
      b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
      c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
      d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
      e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials
   2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*

    a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
    b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
    c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
    d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
    e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
    b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
    c. Demonstrates ability to understand and perform multi-step computations
    d. Demonstrates ability to read, interpret, and use standard measuring devices
    e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
    f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
    g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines
4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
    a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
    b. Demonstrates ability to hear, comprehend, and appropriately follow directions

c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed

5. *Speaking: Organizes ideas and communicates orally*
   a. Demonstrates appropriate listening and speaking skills in personal conversations
   b. Demonstrates ability to choose and organize appropriate words to effectively communicate
   c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
   d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
   e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
   f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
   g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
   a. Demonstrates ability to objectively assess personal strengths and weaknesses
   b. Demonstrates ability to set realistic short-term and long-term goals
   c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
   d. Demonstrates ability to identify potential pitfalls and take evasive actions
   e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response

    f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
    g. Demonstrates maturity in taking responsibility for decisions

2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    a. Demonstrates ability to detect problem through observation, inquiry, or directive
    b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    c. Demonstrates ability to generate alternatives or options for problem solution
    d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    e. Demonstrates ability to initiate and effect solution
    f. Demonstrates ability to take responsibility for outcomes
    g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
    b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
    c. Demonstrates ability to visually discriminate in gross and fine imagery
    d. Demonstrates ability to visualize abstractly
    e. Demonstrates ability to apply visual imagery to applied tasks
4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. Demonstrates mastery of basic reading, math, and language skills through application
    b. Demonstrates ability to translate abstract theory into practical application
    c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
    d. Demonstrates knowledge of good study skills and learning habits

5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. Demonstrates use of simple logic
    b. Demonstrates ability to distinguish relationships
    c. Demonstrates ability to determine and isolate factors in relationships
    d. Demonstrates and applies knowledge through practice
    e. Recognizes that attitudes, skills, and practice are essential to productivity
    f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
    a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
    b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
    c. Demonstrates ability to focus on task at hand and work to completion
    d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
    e. Demonstrates maturity to take responsibility for actions
    f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner
2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
    a. Presents a positive attitude toward tasks
    b. Demonstrates ability to separate work and personal behaviors
    c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
    d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
    e. Demonstrates ability to accept and use constructive criticism
    f. Accepts positive reinforcement in an appropriate manner

3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. Demonstrates appropriate and acceptable social behaviors in interactions
    b. Demonstrates ability to work cooperatively in individual, team, or group situations
    c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
    d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. Accepts personal strengths and weaknesses and uses the same for positive advancement
    b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
    c. Demonstrates ability to formulate and follow personal schedules
    d. Demonstrates ability to wisely use classroom time
    e. Demonstrates use of good study habits and skills
    f. Demonstrates maturity to take responsibility for own actions
5. *Integrity/Honesty: Chooses ethical courses of action*
    a. Knows and demonstrates ability to distinguish between positive and negative behaviors
    b. Demonstrates honesty and integrity in working with peers and supervisors
    c. Takes full responsibility for personal actions
    d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
    e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
    MFG-A1 through MFG-A2;
    MFG-A4;
    MFG-A6; and,
    MFG-K1 through MFG-K3.

WLT 105

MASTER PROGRAM

Survey of Welding Processes and Applications

COURSE SYLLABUS

Total lecture hours: 36 **Total lab hours: 36** **Credit hours: 4**

COURSE DESCRIPTION:

Surveys shielded metal arc, gas tungsten arc, gas metal arc, flux cored arc, and submerged arc welding processes. Metal weldability and weld symbols are considered. Process safety, electrode selection, and process parameters are emphasized. Hard surfacing, using shielded metal arc and oxyacetylene processes and techniques is studied.

PREREQUISITES: NONE

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:
1. Perform arc welding operations;
2. Perform gas welding operations;
3. Perform cut work with a cutting torch; and,
4. Weld using heliarc.

REQUIRED COURSE MATERIALS:

Textbook: *Oxy-Acetylene Handbook*, by Linde, Union Carbide Publisher, Latest Edition
New Lessons in Arc Welding, by Lincoln Electric, Lincoln Electric Publisher, Latest Edition

Lab Manual: None Required

Student Tool List	**Qty. Req'd.**
Oxy-acetylene cutting and welding goggles (mono) with #5 filter lens and one clear plastic lens	1 pair
Friction lighter	1
Wire brush 1" wide with long handle	1
Soap stone	2 pieces
Welder's cap	1
Welding gloves, long gauntlet	1 pair
Chipping hammer	1

Safety glasses	1 pair
Slip joint pliers	1 pair

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video, and demonstrations.

Laboratory: Hands on laboratory activities to enable the students to learn the various aspects of the welding process.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Perform on written, oral, or practical examinations;
4. Perform on outside assignments including writing assignments;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all shop rules and safety regulations as stated in the laboratory manual.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to the course	1
Introduction to oxy-acetylene fusion	1
Oxy-acetylene welding and cutting	2
Introduction to mechanical and physical properties	1
Non-fusion welding	1
Introduction to the oxy-acetylene cutting processes	1
Test #1	1
The shielded metal arc welding process	1
Running a good quality bead in the flat position	1
Introduction to shielded metal arc welding electrodes	2
Shielded metal arc power sources	1
Test #2	1
Weld joints, weld types and weld positions	2
Introduction to fillet welds	1
Test #3	1
Introduction to gas metal arc welding and flux core	

arc welding	2
Short circuiting metal transfer	1
Test #4	1
Power sources for GMAW and FCAW	1
SMAW and FCAW filler metal transfer modes	1
Test #5	1
Shielding gases used with the GMAW process	1
Shielding gases used with the FCAW process	1
Test #6	1
Introduction to gas tungsten arc welding	2
Power sources for GTAW	1
GTAW electrodes	1
Test #7	1
Introduction to submerged arc welding and techniques	1
Submerged arc welding processes	1
Test #8	1
Total Lecture Hours	**36**

LAB OUTLINE:

Lab Topics	Contact Hrs.
The Oxy-Acetylene Welding and Cutting Process	9
Demonstration of setting up and break down of equipment	
A. Welding beads on plate	
(1) Flat position	
(2) Without and with filler	
B. Square butt joints	
(1) Flat and vertical position	
(2) With filler material	
C. Brazing beads on plate	
(1) Flat position	
(2) With filler material	
D. Brazing square butt joint	
(1) Flat and vertical position	
(2) - With filler	
E. Oxy-acetylene cutting	
(1) Cutting to a straight line	
The Shielded Metal Arc Welding Process (SMAW)	9
A. Welding beads on plate	
(1) E6010, E6011 and/or E7018 dependent on availability	
(2) Flat, horizontal and vertical	
B. Welding tee joint	
(1) E6010, E6011 and/or E7018 dependent on	

availability

(2) Flat, horizontal and vertical

The Gas Metal Arc Welding and Flux Core Welding Processes (GMAW) 6

A. Set up 3 machines each process

B. Welding beads on plate, both processes

(1) Have hands on with observers at each station

C. Demonstration of GMAW spot welder

The Gas Tungsten Arc Welding Process (GTAW) 6

A. Set up machines for welding steel and aluminum (2 or 3 each)

B. Welding beads on plate steel

(1) Have hands on with observers

C. Welding bead on plate aluminum

(2) Have hands on with observers

The Submerged Arc Welding Process 6

A. Demonstrate beads on plate

B. Demonstrate running beads roll position

C. Let students have hands on and observation

Total Lab Hours 36

COURSE OBJECTIVES: SCANS COMPETENCIES

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1. Allocates time to complete assigned tasks on schedule
2. Determines and allocates required materials and resources for meeting objectives

3. Evaluates skills, performance, and quality of work and provides feedback

B. Interpersonal: Works with others

1. Participates as a member of the team, contributing to group effort
2. Provides individual assistance/direction to peers as requested
3. Determines and meets expectations
4. Exercises leadership qualities to effectively communicate ideas and make decisions.
5. Negotiates resources in order to accomplish objectives
6. Works well with all members of the class

C. Information: Acquires and uses information

1. Acquires and evaluates information
2. Organizes and maintains information
3. Interprets and communicates information

D. Systems: Understands complex inter-relationships

1. Understands and works well with social, organizational, and technological systems
2. Monitors and corrects performance of system during operation
3. Recommends modifications to system to improve performance

E. Technology: Works with a variety of technologies

1. Chooses relevant procedures, tools, and equipment
2. Applies appropriate procedures and techniques to accomplish tasks
3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks

1. Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules

- a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
- b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
- c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)

    - d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
    - e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
    - a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
    - b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
    - c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
    - d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
    - e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    - a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
    - b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
    - c. Demonstrates ability to understand and perform multi-step computations
    - d. Demonstrates ability to read, interpret, and use standard measuring devices
    - e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
    - f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance

g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines

*4. **Listening:** Receives, attends to, interprets, and responds to verbal messages and other cues*

a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery

b. Demonstrates ability to hear, comprehend, and appropriately follow directions

c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction

d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately

e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds

f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed

*5. **Speaking**: Organizes ideas and communicates orally*

a. Demonstrates appropriate listening and speaking skills in personal conversations

b. Demonstrates ability to choose and organize appropriate words to effectively communicate

c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation

d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes

e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups

f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations

g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

*1. **Decision Making:** Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*

a. Demonstrates ability to objectively assess personal strengths and weaknesses

- b. Demonstrates ability to set realistic short-term and long-term goals
- c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
- d. Demonstrates ability to identify potential pitfalls and take evasive actions
- e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
- f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
- g. Demonstrates maturity in taking responsibility for decisions

2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    - a. Demonstrates ability to detect problem through observation, inquiry, or directive
    - b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    - c. Demonstrates ability to generate alternatives or options for problem solution
    - d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    - e. Demonstrates ability to initiate and effect solution
    - f. Demonstrates ability to take responsibility for outcomes
    - g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    - a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
    - b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
    - c. Demonstrates ability to visually discriminate in gross and fine imagery
    - d. Demonstrates ability to visualize abstractly
    - e. Demonstrates ability to apply visual imagery to applied tasks

4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. Demonstrates mastery of basic reading, math, and language skills through application
    b. Demonstrates ability to translate abstract theory into practical application
    c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
    d. Demonstrates knowledge of good study skills and learning habits
5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. Demonstrates use of simple logic
    b. Demonstrates ability to distinguish relationships
    c. Demonstrates ability to determine and isolate factors in relationships
    d. Demonstrates and applies knowledge through practice
    e. Recognizes that attitudes, skills, and practice are essential to productivity
    f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
    a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
    b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
    c. Demonstrates ability to focus on task at hand and work to completion
    d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
    e. Demonstrates maturity to take responsibility for actions
    f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner
2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
    a. Presents a positive attitude toward tasks

- b. Demonstrates ability to separate work and personal behaviors
- c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
- d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
- e. Demonstrates ability to accept and use constructive criticism
- f. Accepts positive reinforcement in an appropriate manner

3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    - a. Demonstrates appropriate and acceptable social behaviors in interactions
    - b. Demonstrates ability to work cooperatively in individual, team, or group situations
    - c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
    - d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    - a. Accepts personal strengths and weaknesses and uses the same for positive advancement
    - b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
    - c. Demonstrates ability to formulate and follow personal schedules
    - d. Demonstrates ability to wisely use classroom time
    - e. Demonstrates use of good study habits and skills
    - f. Demonstrates maturity to take responsibility for own actions
5. *Integrity/Honesty: Chooses ethical courses of action*
    - a. Knows and demonstrates ability to distinguish between positive and negative behaviors
    - b. Demonstrates honesty and integrity in working with peers and supervisors
    - c. Takes full responsibility for personal actions
    - d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
    - e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
    - MFG-A1 through MFG-A7;
    - MFG-B3;
    - MFG-B5;
    - MFG-C1 through MFG-C7;
    - MFG-C10;
    - MFG-D1;
    - MFG-D3;
    - MFG-D5; and,
    - MFG-E3.
2. *Machinery's Handbook*, Industrial Press, Latest Edition
3. *Welding Technology Today, Principles and Practices*, Stinchcomb, Craig; Prentice Hall Inc., New Jersey, Latest Edition
4. *Welder Handbook*, W-100 E-1 Corp., Publication #51077, Latest Edition
5. Hobart Audio - Visual Training Program, Latest Edition
6. Miller Audio - Visual Training Program, Latest Edition

MASTER Curriculum
Manufacturing Technology
(Associate of Applied Science Degree Program)

		LEC	LAB	CR
First Quarter*				
PSYC 1100	College Success Skills	1	0	1
MFG 100	Machine Tool Practices I	3	9	6
DDT 104	Drafting Principles	2	4	3
MATH 1314	College Algebra	4	0	3
ENGL 1301	Composition I	4	0	3
		14	13	16
Second Quarter*				
MFG 200	Machine Tool Practices II	3	9	6
ENGL 134	Interpersonal Communication	4	0	3
MATH 1316	Plane Trigonometry	4	0	3
CNS 2060	Application Software	1	4	3
		12	13	15
Third Quarter*				
MFG 112	Engineering Materials	2	3	3
OSH 216	Safety and Accident Prevention	2	3	3
PHY 114	Fluid Power I	3	3	4
EST 120	Electrical Applications	3	3	4
WLT 105	Survey of Welding Processes & Applications	3	3	4
		13	15	18
Fourth Quarter*				
MFG 205	CNC Machine Programming	3	3	4
MFG 206	Statics	3	3	4
MFG 301	Manufacturing Processes	3	3	4
DDT 128	Introduction to Computer Drafting	1	4	2
PSYC 2301	General Psychology	4	0	3
		14	13	17
FIFTH QUARTER*				
MFG 302	CAD/CAM I	3	3	4
MFG 216	Tool Design I	2	6	4
MFG 312	Strength of Materials	3	3	4
PHYS 1310	Fundamentals of Physics	4	0	3
	Free Elective	2	0	2
		14	12	17
Sixth Quarter*				
MFG 318	CAD/CAM II	3	3	4
MFG 315	Computer Integrated Manufacturing	2	2	3
MFG 324	Quality Assurance & Statistical Process Control	2	3	3
MFG 322	Engineering Technology Project	4	6	6
		11	14	16
	Program Totals	78	80	99

*** Each quarter is 12 weeks in length**

Fourth Quarter

MFG 205

MASTER PROGRAM

CNC Machine Programming

COURSE SYLLABUS

Total lecture hours: 36 **Total lab hours: 36** **Credit hours: 4**

COURSE DESCRIPTION:

Introduces programming and operation of a computerized numerical control milling machine using manual machine language. Included are linear and circular interpolation, drilling cycle, and repetitive programming.

PREREQUISITES: **Machine Tool Practices I**

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Command and control a machine by numerically coded instructions;
2. Analyze machine operations and their coding on tape;
3. Understand the way the machine reads the taped instructions and acts on them and provides feedback of the results of its action;
4. Apply their knowledge of machine set-up to specific projects of N/C operation.
5. Perform the following:
    a. preparation of manuscript using coded messages to make a machine perform pre-determined machining operations;
    b. read a coded N/C tape;
    c. transform information and specifications from a working drawing to a manuscript;
    d. use coding principles on 2, 3, 4, 5, and 6 axis N/C machines;
    e. use N/C coded messages on point-to-point programming; and,
    f. use N/C coded messages on continuous path contouring programming.

REQUIRED COURSE MATERIALS:

Textbook: *Machine Tool Practices,* Kibbe, Neely, and Meyer, Wiley Pub., Latest Edition

Lab Manual: NONE

Hand Tools/Quantity Required: Basic tool list for Machine Tool Practices I

METHODS OF INSTRUCTION:

Lecture:	Didactic presentations will include lecture, video and demonstrations.
Laboratory:	Laboratory will include computer based exercises as well as hands–on programming of machining processes and setups on the Fadal milling machine center and the Okuma turning center and other machine control simulators.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments involving CNC machine codes, Cartesian coordinate system, G & M codes, fixed and canned cycles, and the basic skills used to produce a CNC program with CAM's Job Plan and Edit Plus module;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments including writing assignments;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all shop rules and safety regulations as stated in the laboratory manual.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
CNC Overview	3
Description of CNC	
Job Opportunities in the CNC field	
Employability Skills in CNC	
Working Safely with CNC machines	
The Structure of a CNC System	3
CNC vs. conventional machining terminology	
5 Considerations before programming begins	
Cartesian Coordinate System	
Process Planning (Mill)	3
Interpreting a part print	
Creating a Job Sheet from a part print	
Introduction to CAM's Job Plan module	
Entering information into a Job Plan	
Programming Format (Mill)	3

Basic CNC code structure for the FADAL mill	
Starting a CNC Program	
Machining examples	
Ending a CNC program	
An introduction to CAM's Edit Plus module and Tape–to–Shape	
Using CAM to simulate machine tool movements	
Programming CNC Machining Operations (Mill)	18
Straight milling	
Drilling operations	
Circular milling	
Process Planning (Lathe)	3
CNC lathe coordinate systems	
Carbide tooling for CNC lathes	
Process planning for the CNC lathe	
Entering tool information into the Job Plan	
Programming the CNC Lathe	3
Basic program structure	
Turning, Facing, Boring, Drilling and Threading	—
Total Lecture Hours	**36**

LAB OUTLINE:

Lab Topics	Contact Hrs.
CNC Lab Organization and Safety	3
Identification of Major CNC Components	3
CNC (Mill) Tooling Systems	3
Introduction to CAM's Programming Software	6
a) Job Plan	
b) Applications	
c) Edit Plus Modules	
Programming CNC Mills	9
a) Basic Program Structure	
b) Linear Milling, Drilling, Circular Milling and Canned Cycles	
CNC Lathe Tooling Systems	3
Programming CNC Lathes	3
Final Project	6
Total Lab Hours	**36**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
  - A. *Resources: Identifies, organizes, plans, and allocates resources*
    1. Allocates time to complete assigned tasks on schedule
    2. Determines and allocates required materials and resources for meeting objectives
    3. Evaluates skills, performance, and quality of work and provides feedback
  - B. *Interpersonal: Works with others*
    1. Participates as a member of the team, contributing to group effort
    2. Provides individual assistance/direction to peers as requested
    3. Determines and meets expectations
    4. Exercises leadership qualities to effectively communicate ideas and make decisions.
    5. Negotiates resources in order to accomplish objectives
    6. Works well with all members of the class
  - C. *Information: Acquires and uses information*
    1. Acquires and evaluates information
    2. Organizes and maintains information
    3. Interprets and communicates information
  - D. *Systems: Understands complex inter-relationships*
    1. Understands and works well with social, organizational, and technological systems
    2. Monitors and corrects performance of system during operation
    3. Recommends modifications to system to improve performance
  - E. *Technology: Works with a variety of technologies*
    1. Chooses relevant procedures, tools, and equipment
    2. Applies appropriate procedures and techniques to accomplish tasks

3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks

1. ***Reading:** Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
    - a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
    - b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
    - c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
    - d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
    - e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials
2. ***Writing:** Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
    - a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
    - b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
    - c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
    - d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
    - e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    a. **Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages**
    b. **Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems**
    c. **Demonstrates ability to understand and perform multi-step computations**
    d. **Demonstrates ability to read, interpret, and use standard measuring devices**
    e. **Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively**
    f. **Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance**
    g. **Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines**
4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
    a. **Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery**
    b. **Demonstrates ability to hear, comprehend, and appropriately follow directions**
    c. **Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction**
    d. **Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately**
    e. **Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds**
    f. **Demonstrates ability and maturity to seek and receive additional individualized instruction as needed**
5. ***Speaking:*** *Organizes ideas and communicates orally*
    a. **Demonstrates appropriate listening and speaking skills in personal conversations**
    b. **Demonstrates ability to choose and organize appropriate words to effectively communicate**

    - c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
    - d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
    - e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
    - f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
    - g. Demonstrates ability to take responsibility for presentations
- B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons
  - *1.* ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    - a. Demonstrates ability to objectively assess personal strengths and weaknesses
    - b. Demonstrates ability to set realistic short-term and long-term goals
    - c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
    - d. Demonstrates ability to identify potential pitfalls and take evasive actions
    - e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
    - f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
    - g. Demonstrates maturity in taking responsibility for decisions
  - *2.* ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    - a. Demonstrates ability to detect problem through observation, inquiry, or directive
    - b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    - c. Demonstrates ability to generate alternatives or options for problem solution
    - d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution

    e. Demonstrates ability to initiate and effect solution
    f. Demonstrates ability to take responsibility for outcomes
    g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
    b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
    c. Demonstrates ability to visually discriminate in gross and fine imagery
    d. Demonstrates ability to visualize abstractly
    e. Demonstrates ability to apply visual imagery to applied tasks
4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. Demonstrates mastery of basic reading, math, and language skills through application
    b. Demonstrates ability to translate abstract theory into practical application
    c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
    d. Demonstrates knowledge of good study skills and learning habits
5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. Demonstrates use of simple logic
    b. Demonstrates ability to distinguish relationships
    c. Demonstrates ability to determine and isolate factors in relationships
    d. Demonstrates and applies knowledge through practice
    e. Recognizes that attitudes, skills, and practice are essential to productivity
    f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*

   a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
   b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
   c. Demonstrates ability to focus on task at hand and work to completion
   d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
   e. Demonstrates maturity to take responsibility for actions
   f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
   a. Presents a positive attitude toward tasks
   b. Demonstrates ability to separate work and personal behaviors
   c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
   d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
   e. Demonstrates ability to accept and use constructive criticism
   f. Accepts positive reinforcement in an appropriate manner

3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   a. Demonstrates appropriate and acceptable social behaviors in interactions
   b. Demonstrates ability to work cooperatively in individual, team, or group situations
   c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
   d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly

4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   a. Accepts personal strengths and weaknesses and uses the same for positive advancement

   - b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   - c. Demonstrates ability to formulate and follow personal schedules
   - d. Demonstrates ability to wisely use classroom time
   - e. Demonstrates use of good study habits and skills
   - f. Demonstrates maturity to take responsibility for own actions
5. *Integrity/Honesty: Chooses ethical courses of action*
   - a. Knows and demonstrates ability to distinguish between positive and negative behaviors
   - b. Demonstrates honesty and integrity in working with peers and supervisors
   - c. Takes full responsibility for personal actions
   - d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
   - e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
   MFG-A1 through MFG-A4;
   MFG-B1 through MFG-B2;
   MFG-B6 through MFG-B8;
   MFG-C1 through MFG-C6;
   MFG-C8;
   MFG-C10;
   MFG-E2 through MFG-E3; and,
   MFG-G1 through MFG-G3.
2. *Machinery's Handbook*, Industrial Press, Latest Edition
3. *Technology of Machine Tools*, McGraw Hill Publishers, Latest Edition

MFG 206

MASTER PROGRAM

Statics

COURSE SYLLABUS

Total lecture hours: 36 **Total lab hours: 36** **Credit hours: 4**

COURSE DESCRIPTION:

Introduces the field of engineering mechanics covering the calculation of forces and moments acting on machine parts, frames, and structures. The equilibrium of concurrent and coplanar force systems, centroids, and friction are studied.

PREREQUISITES: **Plane Trigonometry**

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Acquire fundamentals and be able to apply these principles in the calculations and design of such things as:
    a. Levers;
    b. Structural members;
    c. Inclined planes;
    d. Sheaves;
    e. Machined parts; and,
    f. Structural joints.

REQUIRED COURSE MATERIALS:

Textbook: *Applied Statics and Strength of Materials,* Spiegel and Limbunner, Merrill Publishers, Latest Edition

Lab Manual: NONE

Required Materials:

Engineering paper, green
Scientific Calculator

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Laboratory: Laboratory assignments will require student to solve appropriate static problems.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments including writing assignments;
5. Contribute to class discussions; and,
6. Maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to Mechanics	2
Definition of Mechanics	
Problem in Applied Mechanics	
Procedures in the Solution on Mechanics Problems	
Standards of Workmanship in Problem Solutions	
Basic Principles of Statics	6
Force	
Types of Force	
Characteristics and Units of a Force	
Vector and Scalar Quantities	
Transmissibility of Force	
Types of Force Systems	
Components of a Force	
Resultant of Two Concurrent Forces	
Moments of a Force	
The Principles of Moments; Viraginous Theorem	
Couples	
Resultant of Parallel Forces	
Resolution of a Force into Parallel	
Equilibrium of Force Systems Components	
Principles of Force Equilibrium	
Supports and Support Reactions	
Free-body Diagrams	
Problems in Equilibrium of Coplanar Force Systems	
Coplanar, Parallel Force Systems	3
Resultant of Coplanar, Parallel Forces	
Resultants of Distributed Loads	
Equilibrium of Coplanar, Parallel Force Systems	

Coplanar, Concurrent Force Systems	6
Resultants of Coplanar, Concurrent Force Systems	
Equilibrium of Coplanar, Concurrent Force Systems	
Trusses	
Stresses in Members of Trusses	
Ropes over Sheaves and Pulleys	
Stresses in Trusses; Analytical Method of Joints	
Stresses in Trusses; the Graphical Method of Joints	
Stresses in Trusses; the Graphical Method of Combined Diagrams	
Three-force Members	
Graphical Determination of Reactions Using Three-force Principle	
Coplanar, Nonconcurrent Force Systems	4
Resultant of Coplanar, Nonconcurrent Force Systems	
Equilibrium of Coplanar, Nonconcurrent force Systems	
Determination of Reactions; Graphical String-polygon Method	
Determination of Reactions; Analytical Method	
Pin Reactions; the Method of Members	
Stresses in Trusses; the Method of Sections	
Counter Diagonals in Trusses	
Noncoplanar, Parallel Force Systems	3
Resultant of a Noncoplanar, Parallel Force Systems	
Equilibrium of Noncoplanar, Parallel Force System	
Noncoplanar, Concurrent Force Systems	3
Components of a Force in Space	
Equilibrium of Noncoplanar, Concurrent Force Systems	
Noncoplanar, Nonconcurrent Force Systems	3
Equilibrium of Noncoplanar, Nonconcurrent Force Systems	
Friction	6
Coefficient of Friction, Angle of Friction, and Angle of Repose	
Laws of Friction	
Friction Problems	
Belt Friction	
Rolling Resistance	
Total Lecture Hours	**36**

LAB OUTLINE:

Lab Topics	**Contact Hrs.**
Introduction to Mechanics	2
Basic Principles of Statics	6

Coplanar, Parallel Force Systems	3
Coplanar, Concurrent Force Systems	6
Coplanar, Nonconcurrent Force Systems	4
Noncoplanar, Parallel Force Systems	3
Noncoplanar, Concurrent Force Systems	3
Noncoplanar, Nonconcurrent Force Systems	3
Friction	6
Total Lab Hours	**36**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

- A. *Resources: Identifies, organizes, plans, and allocates resources*
  1. Allocates time to complete assigned tasks on schedule
  2. Determines and allocates required materials and resources for meeting objectives
  3. Evaluates skills, performance, and quality of work and provides feedback
- B. *Interpersonal: Works with others*
  1. Participates as a member of the team, contributing to group effort
  2. Provides individual assistance/direction to peers as requested
  3. Determines and meets expectations
  4. Exercises leadership qualities to effectively communicate ideas and make decisions.
  5. Negotiates resources in order to accomplish objectives
  6. Works well with all members of the class
- C. *Information: Acquires and uses information*
  1. Acquires and evaluates information

    2. Organizes and maintains information
    3. Interprets and communicates information
- D. *Systems: Understands complex inter-relationships*
    1. Understands and works well with social, organizational, and technological systems
    2. Monitors and corrects performance of system during operation
    3. Recommends modifications to system to improve performance
- E. *Technology: Works with a variety of technologies*
    1. Chooses relevant procedures, tools, and equipment
    2. Applies appropriate procedures and techniques to accomplish tasks
    3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

- A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
    1. ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
        - a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
        - b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
        - c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
        - d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
        - e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials
    2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
        - a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning

- b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
- c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
- d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
- e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   - a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
   - b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
   - c. Demonstrates ability to understand and perform multi-step computations
   - d. Demonstrates ability to read, interpret, and use standard measuring devices
   - e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
   - f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
   - g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines
4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
   - a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
   - b. Demonstrates ability to hear, comprehend, and appropriately follow directions
   - c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction

   - d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
   - e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
   - f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed

5. ***Speaking**: Organizes ideas and communicates orally*
   - a. Demonstrates appropriate listening and speaking skills in personal conversations
   - b. Demonstrates ability to choose and organize appropriate words to effectively communicate
   - c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
   - d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
   - e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
   - f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
   - g. Demonstrates ability to take responsibility for presentations

B. Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. ***Decision Making:** Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
   - a. Demonstrates ability to objectively assess personal strengths and weaknesses
   - b. Demonstrates ability to set realistic short-term and long-term goals
   - c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
   - d. Demonstrates ability to identify potential pitfalls and take evasive actions
   - e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
   - f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
   - g. Demonstrates maturity in taking responsibility for decisions

2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    a. Demonstrates ability to detect problem through observation, inquiry, or directive
    b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    c. Demonstrates ability to generate alternatives or options for problem solution
    d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    e. Demonstrates ability to initiate and effect solution
    f. Demonstrates ability to take responsibility for outcomes
    g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
    b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
    c. Demonstrates ability to visually discriminate in gross and fine imagery
    d. Demonstrates ability to visualize abstractly
    e. Demonstrates ability to apply visual imagery to applied tasks
4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. Demonstrates mastery of basic reading, math, and language skills through application
    b. Demonstrates ability to translate abstract theory into practical application
    c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
    d. Demonstrates knowledge of good study skills and learning habits
5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. Demonstrates use of simple logic
    b. Demonstrates ability to distinguish relationships

c. Demonstrates ability to determine and isolate factors in relationships

d. Demonstrates and applies knowledge through practice

e. Recognizes that attitudes, skills, and practice are essential to productivity

f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
   - a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
   - b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
   - c. Demonstrates ability to focus on task at hand and work to completion
   - d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
   - e. Demonstrates maturity to take responsibility for actions
   - f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner
2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
   - a. Presents a positive attitude toward tasks
   - b. Demonstrates ability to separate work and personal behaviors
   - c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
   - d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
   - e. Demonstrates ability to accept and use constructive criticism
   - f. Accepts positive reinforcement in an appropriate manner
3. ***Sociability:*** ***Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings***
   - a. Demonstrates appropriate and acceptable social behaviors in interactions
   - b. Demonstrates ability to work cooperatively in individual, team, or group situations

    c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
    d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly

4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. Accepts personal strengths and weaknesses and uses the same for positive advancement
    b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
    c. Demonstrates ability to formulate and follow personal schedules
    d. Demonstrates ability to wisely use classroom time
    e. Demonstrates use of good study habits and skills
    f. Demonstrates maturity to take responsibility for own actions
5. *Integrity/Honesty: Chooses ethical courses of action*
    a. Knows and demonstrates ability to distinguish between positive and negative behaviors
    b. Demonstrates honesty and integrity in working with peers and supervisors
    c. Takes full responsibility for personal actions
    d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
    e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
    MFG-B1 through MFG-B3;
    MFG-B6; and,
    MFG-B13 through MFG-B14.
2. *Machinery's Handbook*, Industrial Press, Latest Edition
3. *Applied Statics and Strength of Materials*, Spiegel and Limbunner, Merrill Publishers, Latest Edition

MFG 301

MASTER PROGRAM

Manufacturing Processes

COURSE SYLLABUS

Total lecture hours: 36 **Total lab hours: 36** **Credit hours: 4**

COURSE DESCRIPTION:

Studies the processes and materials for manufacturing, including metal casting, hot and cold forming of steel, powder metallurgy, and plastics. Analyzes newer processes such as electrical discharge machining, chemical machining, and ultra-sonic machining; with an emphasis on the economical manufacturing of products.

PREREQUISITES: NONE

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Identify and describe the types of metals used in the shop and their fabricating characteristics;
2. Identify and describe the following processes:
    a. Sand casting;
    b. Shell-mold casting;
    c. Plaster-mold casting;
    d. Investment casting;
    e. Centrifugal casting;
    f. Permanent-mold casting;
    g. Die casting;
    h. Forging;
    I. Hot forming;
    j. Cold forming;
3. Describe the technique used in nondestructive testing;
4. List and describe the steps to produce parts by using powder metallurgy;
5. Discuss the production and use of plastics;
6. Ram up a mold for a sand casting and pour the metal to make the casting;
7. Mold plastic parts using a plastic injection molder; and,
8. Discuss the newer methods used in the manufacturing industry.

REQUIRED COURSE MATERIALS:

Textbook: *Modern Materials and Manufacturing Processes*, John E. Neeley & Richard R. Kibbe, Prentice Hall Career & Technology, Englewood Cliffs, N.J., Latest Edition

Lab Manual: None Required

Student Tool List: Safety glasses

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Laboratory: Laboratory will consist of hands–on activities. Students will operate various conventional metalworking machines to manufacture a product.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Perform on written, oral, or practical examinations;
4. Perform on outside assignments including writing assignments;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all shop rules and safety regulations as stated in the laboratory manual.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to the Course	1
The Manufacturing Industry	3
Material Resource Planning (MRP)	2
Processing of Metals: Casting	3
Processing of Metals: Hot Working	3
Processing of Metals: Cold Working	3
QUIZ I	1
Powder Metallurgy	2
Non-traditional Machining Processes	3

Plastics & Composite Processes	4
QUIZ II	1
Joining Processes	3
Corrosion & Protection for Materials	1
Design, Tooling & Production Lines	5
QUIZ III	1
Total Lecture Hours	**36**

LAB OUTLINE:

Lab Topics	Contact Hrs.
Lab Orientation and Safety	2
Lab Sheet #1 - Stock preparation; measure (semi-precision), shear and debur	3
Lab Sheet #2 - Layout, drill, ream and debur holes	3
Lab Sheet #3 - Metal forming (bending) and countersinking holes	3
Lab Sheet #4 - Metal joining (welding), stress relieving and sawing	3
Mid-term project evaluation and rework	2
Lab Sheet #5 - Surface preparation (sand blast) and surface finish (paint)	3
CNC stock preparation	2
CNC Machining Demonstration and CIM Lab Demonstration	3
Lab Sheet #6 - Component sub-assembly and precision machining activity	3
Lab Sheet #7 - Sub-assembly manufacture (handle)	3
Lab Sheet #8 - Final assembly and test (final project evaluation)	3
Lab clean-up	3
Total Lab Hours	**36**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
  - *A.* ***Resources:** Identifies, organizes, plans, and allocates resources*
    1. Allocates time to complete assigned tasks on schedule
    2. Determines and allocates required materials and resources for meeting objectives
    3. Evaluates skills, performance, and quality of work and provides feedback
  - *B.* ***Interpersonal:** Works with others*
    1. Participates as a member of the team, contributing to group effort
    2. Provides individual assistance/direction to peers as requested
    3. Determines and meets expectations
    4. Exercises leadership qualities to effectively communicate ideas and make decisions.
    5. Negotiates resources in order to accomplish objectives
    6. Works well with all members of the class
  - *C.* ***Information:** Acquires and uses information*
    1. Acquires and evaluates information
    2. Organizes and maintains information
    3. Interprets and communicates information
  - *D.* ***Systems:** Understands complex inter-relationships*
    1. Understands and works well with social, organizational, and technological systems
    2. Monitors and corrects performance of system during operation
    3. Recommends modifications to system to improve performance
  - *E.* ***Technology:** Works with a variety of technologies*
    1. Chooses relevant procedures, tools, and equipment
    2. Applies appropriate procedures and techniques to accomplish tasks
    3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS
  - A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
    - *1.* ***Reading:** Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
      - a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect

a sequence, locate answers, find facts, and infer from written texts

   b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
   c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
   d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
   e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
   b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
   c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
   d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
   e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
   b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems

c. Demonstrates ability to understand and perform multi-step computations
d. Demonstrates ability to read, interpret, and use standard measuring devices
e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines

4. Listening: Receives, attends to, interprets, and responds to verbal messages and other cues

a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
b. Demonstrates ability to hear, comprehend, and appropriately follow directions
c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed

5. Speaking: Organizes ideas and communicates orally

a. Demonstrates appropriate listening and speaking skills in personal conversations
b. Demonstrates ability to choose and organize appropriate words to effectively communicate
c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations

    g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

  1. ***Decision Making:** Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    a. Demonstrates ability to objectively assess personal strengths and weaknesses
    b. Demonstrates ability to set realistic short-term and long-term goals
    c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
    d. Demonstrates ability to identify potential pitfalls and take evasive actions
    e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
    f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
    g. Demonstrates maturity in taking responsibility for decisions

  2. ***Problem Solving:** Recognizes problems and devises and implements plan of action*
    a. Demonstrates ability to detect problem through observation, inquiry, or directive
    b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    c. Demonstrates ability to generate alternatives or options for problem solution
    d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    e. Demonstrates ability to initiate and effect solution
    f. Demonstrates ability to take responsibility for outcomes
    g. Demonstrates ability to effectively problem solve in individual, team, or group situations

  3. ***Seeing Things In the Mind's Eye:** Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual

imagery and meet safety requirements for necessary machinery

b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues

c. Demonstrates ability to visually discriminate in gross and fine imagery

d. Demonstrates ability to visualize abstractly

e. Demonstrates ability to apply visual imagery to applied tasks

4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
   a. Demonstrates mastery of basic reading, math, and language skills through application
   b. Demonstrates ability to translate abstract theory into practical application
   c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
   d. Demonstrates knowledge of good study skills and learning habits

5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   a. Demonstrates use of simple logic
   b. Demonstrates ability to distinguish relationships
   c. Demonstrates ability to determine and isolate factors in relationships
   d. Demonstrates and applies knowledge through practice
   e. Recognizes that attitudes, skills, and practice are essential to productivity
   f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
   a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
   b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
   c. Demonstrates ability to focus on task at hand and work to completion

    d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
    e. Demonstrates maturity to take responsibility for actions
    f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
    a. Presents a positive attitude toward tasks
    b. Demonstrates ability to separate work and personal behaviors
    c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
    d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
    e. Demonstrates ability to accept and use constructive criticism
    f. Accepts positive reinforcement in an appropriate manner
3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. Demonstrates appropriate and acceptable social behaviors in interactions
    b. Demonstrates ability to work cooperatively in individual, team, or group situations
    c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
    d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. Accepts personal strengths and weaknesses and uses the same for positive advancement
    b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
    c. Demonstrates ability to formulate and follow personal schedules
    d. Demonstrates ability to wisely use classroom time
    e. Demonstrates use of good study habits and skills
    f. Demonstrates maturity to take responsibility for own actions
5. ***Integrity/Honesty:*** *Chooses ethical courses of action*

a. Knows and demonstrates ability to distinguish between positive and negative behaviors
b. Demonstrates honesty and integrity in working with peers and supervisors
c. Takes full responsibility for personal actions
d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:*
    MFG-A1 through MFG-A5;
    MFG-A7;
    MFG-B6;
    MFG-C1 through MFG-C3;
    MFG-C5 through MFG-C10;
    MFG-D1 through MFG-D2;
    MFG-D4;
    MFG-E2; and,
    MFG-E5 through MFG-E6.
2. *Machinery's Handbook*, Industrial Press, Latest Edition
3. *Technology of Machine Tools*, McGraw Hill Publishers, Latest Edition

MASTER PROGRAM

Introduction to Computer Drafting

COURSE SYLLABUS

Total lecture hours: 12 **Total lab hours: 48** **Credit hours: 2**

COURSE DESCRIPTION:

Introduces the student to Computer-Aided Drafting (CAD). This introduction involves equipment, software, and basic command logic. Graphic images are created using introductory level commands.

PREREQUISITES: NONE

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Identify computer hardware, terminology and procedures for start-up and shutdown of the computer;
2. Input information through the use of various input devices;
3. Use the SETTINGS menu commands to establish operating parameters in a drawing;
4. Use the LINE command to demonstrate competency in the Cartesian coordinate system;
5. Use the DISPLAY menu commands to manipulate the drawing image;
6. Apply basic DRAW menu and EDIT menu commands to create a drawing;
7. Use the INQUIRY menu commands to examine the database of a drawing;
8. Use the DOS and UTILITY menu commands to manage file;
9. Set up the specifications within the PLOT command for producing a hard copy of a drawing;
10. Use LAYER menu commands to create separations with a drawing by color and line type; and,
11. Use the BLOCK menu commands to create and manipulate symbols.

REQUIRED COURSE MATERIALS:

Textbook: *AutoCAD and Its Applications*, Terence Shumaker/David A. Madsen, Latest Edition

Materials:	2 - DSHD 3½" diskettes 1 Ream of plain bond paper (20 lb.) Notebook Paper Felt tip pen 1 Pkg Calcomp Plotter Pens - Assorted Colors

METHODS OF INSTRUCTION:

Lecture:	Classroom presentations will include lecture, video and demonstrations. Computer assisted instruction will be used.
Laboratory:	Laboratory will be a hands–on drawing process using computer hardware, software, plotters and printers.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments including writing assignments;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all safety regulations as stated in the class policies.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to Course	
Required Materials and Tests	
Class Policies and Safety Concerns	
System Orientation	
Operating Parameters and Drawing Aids	1
Cartesian-Coordinates	1
Display Commands	1
Draw Commands	1
Edit Commands	1
Text Commands	1
Inquiry Commands	1
DOS/Utility Commands	1
Plot Specifications	1
Layer Command	1
Blocks	1

Dimensioning		1
Manufacturing/CAD Project		—
	Total Lecture Hours	**12**

LAB OUTLINE:

Lab Topics		**Contact Hrs.**
System Orientation		2
Operating Parameters		2
Cartesian Coordinates		4
Displaying Different Views		1
Drawing Entities		4
Editing Existing Entities		2
Text on the Drawings		2
Inquiry - Obtaining Database Information		1
DOS/Utility Commands		1
Plotting		1
Using Layers		2
Creating Blocks		4
Dimensioning Drawings		4
Project		18
	Total Lab Hours	**48**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
   A. Resources: Identifies, organizes, plans, and allocates resources
      1. Allocates time to complete assigned tasks on schedule
      2. Determines and allocates required materials and resources for meeting objectives

    3. Evaluates skills, performance, and quality of work and provides feedback

B. *Interpersonal: Works with others*
    1. Participates as a member of the team, contributing to group effort
    2. Provides individual assistance/direction to peers as requested
    3. Determines and meets expectations
    4. Exercises leadership qualities to effectively communicate ideas and make decisions.
    5. Negotiates resources in order to accomplish objectives
    6. Works well with all members of the class

C. *Information: Acquires and uses information*
    1. Acquires and evaluates information
    2. Organizes and maintains information
    3. Interprets and communicates information

D. *Systems: Understands complex inter-relationships*
    1. Understands and works well with social, organizational, and technological systems
    2. Monitors and corrects performance of system during operation
    3. Recommends modifications to system to improve performance

E. *Technology: Works with a variety of technologies*
    1. Chooses relevant procedures, tools, and equipment
    2. Applies appropriate procedures and techniques to accomplish tasks
    3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
    1. *Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
        a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
        b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
        c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)

    - d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
    - e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
    - a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
    - b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
    - c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
    - d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
    - e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    - a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
    - b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
    - c. Demonstrates ability to understand and perform multi-step computations
    - d. Demonstrates ability to read, interpret, and use standard measuring devices
    - e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
    - f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance

g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines

4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*

a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery

b. Demonstrates ability to hear, comprehend, and appropriately follow directions

c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction

d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately

e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds

f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed

5. ***Speaking:*** *Organizes ideas and communicates orally*

a. Demonstrates appropriate listening and speaking skills in personal conversations

b. Demonstrates ability to choose and organize appropriate words to effectively communicate

c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation

d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes

e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups

f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations

g. Demonstrates ability to take responsibility for presentations

B. Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*

a. Demonstrates ability to objectively assess personal strengths and weaknesses

   b. Demonstrates ability to set realistic short-term and long-term goals
   c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
   d. Demonstrates ability to identify potential pitfalls and take evasive actions
   e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
   f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
   g. Demonstrates maturity in taking responsibility for decisions

2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
   a. Demonstrates ability to detect problem through observation, inquiry, or directive
   b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
   c. Demonstrates ability to generate alternatives or options for problem solution
   d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
   e. Demonstrates ability to initiate and effect solution
   f. Demonstrates ability to take responsibility for outcomes
   g. Demonstrates ability to effectively problem solve in individual, team, or group situations

3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
   a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
   b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
   c. Demonstrates ability to visually discriminate in gross and fine imagery
   d. Demonstrates ability to visualize abstractly
   e. Demonstrates ability to apply visual imagery to applied tasks

4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
   - a. Demonstrates mastery of basic reading, math, and language skills through application
   - b. Demonstrates ability to translate abstract theory into practical application
   - c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
   - d. Demonstrates knowledge of good study skills and learning habits
5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   - a. Demonstrates use of simple logic
   - b. Demonstrates ability to distinguish relationships
   - c. Demonstrates ability to determine and isolate factors in relationships
   - d. Demonstrates and applies knowledge through practice
   - e. Recognizes that attitudes, skills, and practice are essential to productivity
   - f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
   - a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
   - b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
   - c. Demonstrates ability to focus on task at hand and work to completion
   - d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
   - e. Demonstrates maturity to take responsibility for actions
   - f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner
2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
   - a. Presents a positive attitude toward tasks

   - b. Demonstrates ability to separate work and personal behaviors
   - c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
   - d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
   - e. Demonstrates ability to accept and use constructive criticism
   - f. Accepts positive reinforcement in an appropriate manner

3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   - a. Demonstrates appropriate and acceptable social behaviors in interactions
   - b. Demonstrates ability to work cooperatively in individual, team, or group situations
   - c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
   - d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly

4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   - a. Accepts personal strengths and weaknesses and uses the same for positive advancement
   - b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   - c. Demonstrates ability to formulate and follow personal schedules
   - d. Demonstrates ability to wisely use classroom time
   - e. Demonstrates use of good study habits and skills
   - f. Demonstrates maturity to take responsibility for own actions

5. ***Integrity/Honesty:*** *Chooses ethical courses of action*
   - a. Knows and demonstrates ability to distinguish between positive and negative behaviors
   - b. Demonstrates honesty and integrity in working with peers and supervisors
   - c. Takes full responsibility for personal actions
   - d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
   - e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
    - MFG-A1;
    - MFG-A4;
    - MFG-B1;
    - MFG-B3;
    - MFG-B5;
    - MFG-B8;
    - MFG-C1 through MFG-C3;
    - MFG-C5 through MFG-C6; and,
    - MFG-I1 through MFG-I3.

PSYC 2301

MASTER PROGRAM

General Psychology

COURSE SYLLABUS

Total lecture hours: 48 **Total lab hours: 0** **Credit hours: 3**

COURSE DESCRIPTION:

Surveys the major topics in psychology, including an introduction to the study of behavior and the factors that determine and affect behavior.

PREREQUISITES: NONE

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Differentiate between the popular image of psychology and the more accurate picture of the nature and content areas of psychology;
2. Recognize the major concepts, vocabulary, theories, research findings and principles of psychology;
3. Demonstrate application of the basic principles of psychological theory to real–life situations;
4. Have an increased understanding of similarities and differences among the people of the world as they relate to psychological principles, concepts, and issues;
5. Integrate overall knowledge of psychology by analyzing, synthesizing, and evaluating own behavior to determine how well he/she is using and will continue to use the information acquired in this course to:
    a. Make a more effective personal-social adjustment to his/her environment;
    b. Develop a more open-minded attitude about human behavior; and,
    c. Become more tolerant of own and others' behavior by understanding some of its determinants.

REQUIRED COURSE MATERIALS:

Textbooks: *Exploring Psychology*, New York, New York: Worth Publishers, Latest Edition
Psychology In Action, New York, New York: John Wiley and Sons, Latest Edition

Supplies: Scantron Answer Sheets

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete assignments;
2. Apply theory to assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments, including writing assignments, and oral presentations;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all rules and safety regulations.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to General Psychology	4
Course Orientation	
Introduction to Psychology	
Biological Roots of Behavior	8
Biological Roots of Behavior	
The Developing Person	
Sensation, Perception, and Consciousness	8
Sensation and Perception	
States of Consciousness	
Learning, Memory, and Intelligence	8
Learning	
Memory	
Thinking and Intelligence	
Motivation, Emotions, Stress and Health	8
Motivation	
Emotions, Stress, and Health	
Personality and Psychological Disorders	8
Personality	
Psychological Disorders	

Social Basis of Behavior	4
Social Diversity	
Course Wrap-Up	—
Total Lecture Hours	48

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
  A. Resources: Identifies, organizes, plans, and allocates resources
    1. Allocates time to complete assigned tasks on schedule
    2. Determines and allocates required materials and resources for meeting objectives
    3. Evaluates skills, performance, and quality of work and provides feedback
  B. Interpersonal: Works with others
    1. Participates as a member of the team, contributing to group effort
    2. Provides individual assistance/direction to peers as requested
    3. Determines and meets expectations
    4. Exercises leadership qualities to effectively communicate ideas and make decisions.
    5. Negotiates resources in order to accomplish objectives
    6. Works well with all members of the class
  C. Information: Acquires and uses information
    1. Acquires and evaluates information
    2. Organizes and maintains information
    3. Interprets and communicates information
  D. Systems: Understands complex inter-relationships
    1. Understands and works well with social, organizational, and technological systems

2. Monitors and corrects performance of system during operation
3. Recommends modifications to system to improve performance

E. Technology: Works with a variety of technologies
1. Chooses relevant procedures, tools, and equipment
2. Applies appropriate procedures and techniques to accomplish tasks
3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

A. Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks

*1. **Reading:** Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*

a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts

b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study

c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)

d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner

e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

*2. **Writing:** Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*

a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning

b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.

   c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
   d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
   e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
   b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
   c. Demonstrates ability to understand and perform multi-step computations
   d. Demonstrates ability to read, interpret, and use standard measuring devices
   e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
   f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
   g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines

4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
   a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
   b. Demonstrates ability to hear, comprehend, and appropriately follow directions
   c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
   d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
   e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds

f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed

5. Speaking: Organizes ideas and communicates orally

a. Demonstrates appropriate listening and speaking skills in personal conversations

b. Demonstrates ability to choose and organize appropriate words to effectively communicate

c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation

d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes

e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups

f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations

g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative

a. Demonstrates ability to objectively assess personal strengths and weaknesses

b. Demonstrates ability to set realistic short-term and long-term goals

c. Demonstrates ability to recognize and distinguish between positive and negative alternatives

d. Demonstrates ability to identify potential pitfalls and take evasive actions

e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response

f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives

g. Demonstrates maturity in taking responsibility for decisions

2. Problem Solving: Recognizes problems and devises and implements plan of action

a. Demonstrates ability to detect problem through observation, inquiry, or directive

- b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
- c. Demonstrates ability to generate alternatives or options for problem solution
- d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
- e. Demonstrates ability to initiate and effect solution
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    - a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
    - b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
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    - d. Demonstrates ability to visualize abstractly
    - e. Demonstrates ability to apply visual imagery to applied tasks
4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    - a. Demonstrates mastery of basic reading, math, and language skills through application
    - b. Demonstrates ability to translate abstract theory into practical application
    - c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
    - d. Demonstrates knowledge of good study skills and learning habits
5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    - a. Demonstrates use of simple logic
    - b. Demonstrates ability to distinguish relationships
    - c. Demonstrates ability to determine and isolate factors in relationships
    - d. Demonstrates and applies knowledge through practice

e. Recognizes that attitudes, skills, and practice are essential to productivity

f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*

a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals

b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner

c. Demonstrates ability to focus on task at hand and work to completion

d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time

e. Demonstrates maturity to take responsibility for actions

f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*

a. Presents a positive attitude toward tasks

b. Demonstrates ability to separate work and personal behaviors

c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors

d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors

e. Demonstrates ability to accept and use constructive criticism

f. Accepts positive reinforcement in an appropriate manner

3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*

a. Demonstrates appropriate and acceptable social behaviors in interactions

b. Demonstrates ability to work cooperatively in individual, team, or group situations

c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner

    d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly

4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. Accepts personal strengths and weaknesses and uses the same for positive advancement
    b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
    c. Demonstrates ability to formulate and follow personal schedules
    d. Demonstrates ability to wisely use classroom time
    e. Demonstrates use of good study habits and skills
    f. Demonstrates maturity to take responsibility for own actions

5. *Integrity/Honesty: Chooses ethical courses of action*
    a. Knows and demonstrates ability to distinguish between positive and negative behaviors
    b. Demonstrates honesty and integrity in working with peers and supervisors
    c. Takes full responsibility for personal actions
    d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
    e. Demonstrates positive work and social ethics in undertakings

MASTER Curriculum
Manufacturing Technology
(Associate of Applied Science Degree Program)

First Quarter*		LEC	LAB	CR
PSYC 1100	College Success Skills	1	0	1
MFG 100	Machine Tool Practices I	3	9	6
DDT 104	Drafting Principles	2	4	3
MATH 1314	College Algebra	4	0	3
ENGL 1301	Composition I	4	0	3
		14	13	16
Second Quarter*				
MFG 200	Machine Tool Practices II	3	9	6
ENGL 134	Interpersonal Communication	4	0	3
MATH 1316	Plane Trigonometry	4	0	3
CNS 2060	Application Software	1	4	3
		12	13	15
Third Quarter*				
MFG 112	Engineering Materials	2	3	3
OSH 216	Safety and Accident Prevention	2	3	3
PHY 114	Fluid Power I	3	3	4
EST 120	Electrical Applications	3	3	4
WLT 105	Survey of Welding Processes & Applications	3	3	4
		13	15	18
Fourth Quarter*				
MFG 205	CNC Machine Programming	3	3	4
MFG 206	Statics	3	3	4
MFG 301	Manufacturing Processes	3	3	4
DDT 128	Introduction to Computer Drafting	1	4	2
PSYC 2301	General Psychology	4	0	3
		14	13	17
FIFTH QUARTER*				
MFG 302	CAD/CAM I	3	3	4
MFG 216	Tool Design I	2	6	4
MFG 312	Strength of Materials	3	3	4
PHYS 1310	Fundamentals of Physics	4	0	3
	Free Elective	2	0	2
		14	12	17
Sixth Quarter*				
MFG 318	CAD/CAM II	3	3	4
MFG 315	Computer Integrated Manufacturing	2	2	3
MFG 324	Quality Assurance & Statistical Process Control	2	3	3
MFG 322	Engineering Technology Project	4	6	6
		11	14	16
	Program Totals	78	80	99

*** Each quarter is 12 weeks in length**

MFG 302

MASTER PROGRAM

CAD/CAM I

COURSE SYLLABUS

Total lecture hours: 36 **Total lab hours: 36** **Credit hours: 4**

COURSE DESCRIPTION:

Introduces "Process Modeling" utilizing the CNC graphics programming system, CAM. Using engineering drawings, students will program various parts for both CNC mills and CNC lathes. Related topics include: job planning, tool selection, construction of a process model, tool path verification, simulation, quality control, CAD/CAM data transfer, and CNC code generation.

PREREQUISITES: NONE

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Demonstrate DOS drive commands successfully;
2. Create a basic procedure process for machining a part on a machine center and on a turning center, including:
    a. machine selection;
    b. tool selection and application;
    c. operational sequence;
    d. speed, feed and depth of cut;
    e. tool length offsets;
3. Develop a complete job plan using CAM software;
4. Demonstrate the ability to develop job plans from print information;
5. Demonstrate the interaction of menus to develop a SHAPE file in the CAM graphics system;
6. Demonstrate the manipulation of files to successfully complete a graphics project within a CAM system;
7. Develop tool path geometry and part geometry to produce accurately coded information for both CNC mills and lathes;
8. Demonstrate the use of plotters and printers to produce accurate documents;
9. Use time saving enhancement features of a graphics programming system to develop tool path and part geometry and perform editing functions; and,
10. Perform and demonstrate the ability to transfer CAD files to CAM files and CAM files to CAD files.

REQUIRED COURSE MATERIALS:

Textbook: *SMARTCAM-2D*, Pelton, TSTC Publication, Latest Edition
Lab Manual: NONE

Materials and/or Supplies: 2 - double sided, high density 3½" floppy diskettes

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, overheads and CAM and related software demonstrations.

Laboratory: Laboratory will be hands–on (computer based) process modeling using the CAM System.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Demonstrate the ability to use DOS commands;
2. Create a basic procedure for machining a part on a machine center and a turning center, including: machine tool selection, tool selection and application, operational sequences, speeds, feeds and depth of cuts and tool length offsets;
3. Develop job plans using CAM;
4. Demonstrate the ability to develop a SHAPE file in the CAM graphics system;
5. Demonstrate the ability to manipulate files to successfully complete a graphics project within a CAM system;
6. Create part profiles and part geometry to produce accurately coded information for both CNC lathes and mills;
7. Utilize plotters and printers to produce accurate documents;
8. Perform and demonstrate the ability to transfer CAD files to CAM files and CAM files to CAD files;
9. Generate a tool path from CAD to CAM files;
10. Edit a tool path from a CAD file and proof the tool path from a CAD file;
11. Satisfactorily perform on written, oral, and practical examinations;
12. Satisfactorily perform on outside assignments including writing assignments;
13. Contribute to class discussions; and,
14. Maintain attendance per current policy.

LECTURE OUTLINE:

Lecture Topic	Contact Hrs.
CNC/CAD/CAM Overview	
Description of CNC	
Computer Systems Review	
Job Opportunities in the CAM Field	
Employability Skills in CAM	
The Structure of a CAM System	
From Print to Part	
The Graphical User Interface	
Working with CAM's Display Areas	
Process Planning (Mill)	
Interpreting a Part Print	
Creating a Job Sheet from a Part Print	
Entering Tool Information into the Job Plan	
Review for Quiz 1	
Quiz 1	
Return and Discuss Quiz 1	
Working with a CNC Process Model (Mill)	
Starting a CNC Process Model	
Roughing and Finishing an Existing Process Model	
Modifying Existing Geometry	
Methods for Creating Geometry for the Process Model	
Generating CNC Code with a CAM System	
Basic NC Code Structure	
Locating the Data Source for Code Generation	
How a CAM System Generates CNC Code	
Review for Quiz 2	
QUIZ 2	
Additional Modeling Practices	
Pocketing and Facing with Islands/Notches, etc.	
Re-sequencing Machining Operations	
Rotate, Move, Copy, Mirror and Scale Commands	
Process Planning (Lathe)	
CNC Lathe Coordinate Systems	
Carbide Tooling for CNC Lathes	
Entering Tool Information into the Job Plan	
Working with a CNC Process Model (Lathe)	
Turning, Facing, Boring and Drilling	
Review for Quiz 3	
Quiz 3	
Additional Modeling Practices	
Threading Cycles and Grooving Cycle	
Roughing for Turning and Facing Operations	

Working with CAD Geometry
Conventions of CAD Geometry
Using a CAM System to Transfer CAD Geometry
Working with CAD Geometry in a CAM System
Transferring a CNC Process Model to a CAD System
Quiz 4 Review
Quiz 4

Total Lecture Hours 36

LAB OUTLINE:

Lab Topics	Contact Hrs.
Job Plan	2
"Tryit" Exercises 1 thru 5	2
Simple Part Profile (Mill 1)	2
Simple Part Profile (Mill 2)	2
Profile with Roughing (Mill 3)	2
Using Multiple Tools (Mill 4)	2
Using Multiple Tools and Roughing (Mill 5)	2
Using Layers, Islands and Rough Facing (Mill 6)	3
Rough Processing (Mill 7)	2
Converting Geometry to Profiles, Using Copy (Mill 8)	2
Complex Part Geometry With Multiple Tools (Mill 9)	2
Using Rotate and Move Commands (Mill 10)	2
Roughing, Pocketing Drilling and Tapping (Mill 11)	2
Complex Modeling, Rotating, Moving Scaling (Mill 12)	3
Turning Lengths and Diameters (Lathe 1)	2
O.D. and I.D. Contour Turning (Lathe 2)	2
Multiple Tool with Roughing (Lathe 3)	2
Total Lab Hours	**36**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
  A. *Resources: Identifies, organizes, plans, and allocates resources*
    1. Allocates time to complete assigned tasks on schedule
    2. Determines and allocates required materials and resources for meeting objectives
    3. Evaluates skills, performance, and quality of work and provides feedback
  B. *Interpersonal: Works with others*
    1. Participates as a member of the team, contributing to group effort
    2. Provides individual assistance/direction to peers as requested
    3. Determines and meets expectations
    4. Exercises leadership qualities to effectively communicate ideas and make decisions.
    5. Negotiates resources in order to accomplish objectives
    6. Works well with all members of the class
  C. *Information: Acquires and uses information*
    1. Acquires and evaluates information
    2. Organizes and maintains information
    3. Interprets and communicates information
  D. *Systems: Understands complex inter-relationships*
    1. Understands and works well with social, organizational, and technological systems
    2. Monitors and corrects performance of system during operation
    3. Recommends modifications to system to improve performance
  E. *Technology: Works with a variety of technologies*
    1. Chooses relevant procedures, tools, and equipment
    2. Applies appropriate procedures and techniques to accomplish tasks
    3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS
  A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
    1. Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules
      a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts

   b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
   c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
   d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
   e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
   b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
   c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
   d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
   e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
   b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
   c. Demonstrates ability to understand and perform multi-step computations

   - d. Demonstrates ability to read, interpret, and use standard measuring devices
   - e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
   - f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
   - g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines

4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
   - a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
   - b. Demonstrates ability to hear, comprehend, and appropriately follow directions
   - c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
   - d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
   - e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
   - f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed
5. *Speaking: Organizes ideas and communicates orally*
   - a. Demonstrates appropriate listening and speaking skills in personal conversations
   - b. Demonstrates ability to choose and organize appropriate words to effectively communicate
   - c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
   - d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
   - e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
   - f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
   - g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    a. Demonstrates ability to objectively assess personal strengths and weaknesses
    b. Demonstrates ability to set realistic short-term and long-term goals
    c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
    d. Demonstrates ability to identify potential pitfalls and take evasive actions
    e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
    f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
    g. Demonstrates maturity in taking responsibility for decisions
2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    a. Demonstrates ability to detect problem through observation, inquiry, or directive
    b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    c. Demonstrates ability to generate alternatives or options for problem solution
    d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    e. Demonstrates ability to initiate and effect solution
    f. Demonstrates ability to take responsibility for outcomes
    g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery

    - b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
    - c. Demonstrates ability to visually discriminate in gross and fine imagery
    - d. Demonstrates ability to visualize abstractly
    - e. Demonstrates ability to apply visual imagery to applied tasks
  - 4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    - a. Demonstrates mastery of basic reading, math, and language skills through application
    - b. Demonstrates ability to translate abstract theory into practical application
    - c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
    - d. Demonstrates knowledge of good study skills and learning habits
  - 5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    - a. Demonstrates use of simple logic
    - b. Demonstrates ability to distinguish relationships
    - c. Demonstrates ability to determine and isolate factors in relationships
    - d. Demonstrates and applies knowledge through practice
    - e. Recognizes that attitudes, skills, and practice are essential to productivity
    - f. Demonstrates ability to discriminate between positive and negative, and act accordingly
- C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty
  - 1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
    - a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
    - b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
    - c. Demonstrates ability to focus on task at hand and work to completion
    - d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time

   e. Demonstrates maturity to take responsibility for actions
   f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
   a. Presents a positive attitude toward tasks
   b. Demonstrates ability to separate work and personal behaviors
   c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
   d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
   e. Demonstrates ability to accept and use constructive criticism
   f. Accepts positive reinforcement in an appropriate manner
3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   a. Demonstrates appropriate and acceptable social behaviors in interactions
   b. Demonstrates ability to work cooperatively in individual, team, or group situations
   c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
   d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   a. Accepts personal strengths and weaknesses and uses the same for positive advancement
   b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   c. Demonstrates ability to formulate and follow personal schedules
   d. Demonstrates ability to wisely use classroom time
   e. Demonstrates use of good study habits and skills
   f. Demonstrates maturity to take responsibility for own actions
5. ***Integrity/Honesty:*** *Chooses ethical courses of action*
   a. Knows and demonstrates ability to distinguish between positive and negative behaviors

    b. **Demonstrates honesty and integrity in working with peers and supervisors**
    c. **Takes full responsibility for personal actions**
    d. **Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable**
    e. **Demonstrates positive work and social ethics in undertakings**

Appropriate Reference Materials:

1. MASTER Technical Modules:
    MFG-B1 through MFG-B3;
    MFG-B6 through MFG-B8;
    MFG-C1 through MFG-C8;
    MFG-D1;
    MFG-G1 through MFG-G7;
    MFG-H1 through MFG-H3; and,
    MFG-I1.
2. *SMARTCAM Advanced 3-D Machining Reference Manual*, Latest Edition
3. *Technology of Machine Tools*, McGraw Hill Publishers, Latest Edition
4. Machine Tool Catalogs

MASTER PROGRAM

Tool Design I

COURSE SYLLABUS

Total lecture hours: 24 **Total lab hours: 72** **Credit hours: 4**

COURSE DESCRIPTION:

Requires the students to set up and machine work pieces using the lathe, vertical mill, drill press, and surface grinders. Fasteners, surface finish, and machining techniques typical of tool and die making are used.

PREREQUISITES: **Machine Tool Practices I; and Drafting Principles**

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Learn the procedures used to solve shop problems resulting from design;
2. Learn to look for alternate methods of manufacture where basic shop equipment does not lend itself to production of designed components; and,
3. Recognize where a standard catalog item may replace non-standard items and how to use the catalog in choosing replacement for non-standard items.

REQUIRED COURSE MATERIALS:

Textbook: *Machine Tool Practices,* Kibbe, Neely, and Meyer, Wiley Pub., Latest Edition
Tool Design, LeCain & Goold, McGraw-Hill Publishers, Latest Edition

Hand Tools/Quantity Required:	
Tool Box	1
Safety Glasses	1 pair
6 inch Ruler	1/8, 1/16, 1/32, and 1/64 inch
Ball Peen Hammer	1
10 inch Adjustable Wrench	1
Center Punch	1
Magic marker, Jumbo, black.	1
Aluminum Oxide Cloth, 9" X 11", 240 Grit	2 sheets
Aluminum Oxide Cloth, 9" X 11", 320 Grit	2 sheets

Tool Steel, 3/8", H.S.S.	2
Flat Mill Bastard File, 10 inch.	1
File Handle	1
Allen Wrench Set, Long English and Metric	1 each
Center Drill #3	1
Scribe	1
Center Gage	1
Screw Driver, 8 inch	1
File Card Brush	1
0-6 inch Dial Calipers	1
Shop Apron (blue denim)	1
Shop Towels (1 roll)	1

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Laboratory: Laboratory will be hands–on activities.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theories of design considerations to laboratory assignments involving design and production of jigs, fixtures and other production tooling;
3. Demonstrate a knowledge of alternate manufacturing processes by selecting processes that reduce or eliminate primary and/or secondary machining operations;
4. Satisfactorily perform on written, oral, and practical examinations;
5. Satisfactorily perform on outside assignments including writing assignments;
6. Contribute to class discussions;
7. Maintain attendance per current policy; and,
8. Follow all shop rules and safety regulations as stated in the laboratory manual.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to Tool Design	
Safety	
Tool Grinding	

Review Measuring Tools
Review Machine Tools and Operations
  The Drill Press
  Engine Lathes
  Vertical Milling Machines
Introduction to Surface Grinding
Special Tooling
Problems Resulting from Design
Toolmaker Practices
Tooling Materials and Heat Treatment
Location and Clamping Methods
Design of Drill Jigs
Design of Fixtures
Using Standard vs. Non-Standard Parts

Total Lecture Hours 36

LAB OUTLINE:

Lab Topics	Contact Hrs.
Identifying Design Problems	20
Solving Manufacturing Problems	40
Evaluating the Design Considerations	12
Total Lab Hours	72

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

A. *Resources: Identifies, organizes, plans, and allocates resources*

1. Allocates time to complete assigned tasks on schedule

2. Determines and allocates required materials and resources for meeting objectives
3. Evaluates skills, performance, and quality of work and provides feedback

B. *Interpersonal: Works with others*

1. Participates as a member of the team, contributing to group effort
2. Provides individual assistance/direction to peers as requested
3. Determines and meets expectations
4. Exercises leadership qualities to effectively communicate ideas and make decisions.
5. Negotiates resources in order to accomplish objectives
6. Works well with all members of the class

C. *Information: Acquires and uses information*

1. Acquires and evaluates information
2. Organizes and maintains information
3. Interprets and communicates information

D. *Systems: Understands complex inter-relationships*

1. Understands and works well with social, organizational, and technological systems
2. Monitors and corrects performance of system during operation
3. Recommends modifications to system to improve performance

E. *Technology: Works with a variety of technologies*

1. Chooses relevant procedures, tools, and equipment
2. Applies appropriate procedures and techniques to accomplish tasks
3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

A. **Basic Skills**: Reads, writes, performs arithmetic and mathematical operations, listens and speaks

1. ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*

a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts

b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study

c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)

d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner

e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*

   a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning

   b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.

   c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered

   d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner

   e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*

   a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages

   b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems

   c. Demonstrates ability to understand and perform multi-step computations

   d. Demonstrates ability to read, interpret, and use standard measuring devices

   e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively

   f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance

g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines

4. Listening: Receives, attends to, interprets, and responds to verbal messages and other cues

a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery

b. Demonstrates ability to hear, comprehend, and appropriately follow directions

c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction

d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately

e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds

f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed

5. Speaking: Organizes ideas and communicates orally

a. Demonstrates appropriate listening and speaking skills in personal conversations

b. Demonstrates ability to choose and organize appropriate words to effectively communicate

c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation

d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes

e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups

f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations

g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative

a. Demonstrates ability to objectively assess personal strengths and weaknesses

- b. Demonstrates ability to set realistic short-term and long-term goals
- c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
- d. Demonstrates ability to identify potential pitfalls and take evasive actions
- e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
- f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
- g. Demonstrates maturity in taking responsibility for decisions

2. ***Problem Solving:** Recognizes problems and devises and implements plan of action*
   - a. Demonstrates ability to detect problem through observation, inquiry, or directive
   - b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
   - c. Demonstrates ability to generate alternatives or options for problem solution
   - d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
   - e. Demonstrates ability to initiate and effect solution
   - f. Demonstrates ability to take responsibility for outcomes
   - g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. ***Seeing Things In the Mind's Eye:** Organizes, and processes symbols, pictures, graphs, objects, and other information*
   - a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
   - b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
   - c. Demonstrates ability to visually discriminate in gross and fine imagery
   - d. Demonstrates ability to visualize abstractly
   - e. Demonstrates ability to apply visual imagery to applied tasks

4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. Demonstrates mastery of basic reading, math, and language skills through application
    b. Demonstrates ability to translate abstract theory into practical application
    c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
    d. Demonstrates knowledge of good study skills and learning habits
5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. Demonstrates use of simple logic
    b. Demonstrates ability to distinguish relationships
    c. Demonstrates ability to determine and isolate factors in relationships
    d. Demonstrates and applies knowledge through practice
    e. Recognizes that attitudes, skills, and practice are essential to productivity
    f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
    a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
    b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
    c. Demonstrates ability to focus on task at hand and work to completion
    d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
    e. Demonstrates maturity to take responsibility for actions
    f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner
2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
    a. Presents a positive attitude toward tasks

   - b. Demonstrates ability to separate work and personal behaviors
   - c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
   - d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
   - e. Demonstrates ability to accept and use constructive criticism
   - f. Accepts positive reinforcement in an appropriate manner

3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   - a. Demonstrates appropriate and acceptable social behaviors in interactions
   - b. Demonstrates ability to work cooperatively in individual, team, or group situations
   - c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
   - d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   - a. Accepts personal strengths and weaknesses and uses the same for positive advancement
   - b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   - c. Demonstrates ability to formulate and follow personal schedules
   - d. Demonstrates ability to wisely use classroom time
   - e. Demonstrates use of good study habits and skills
   - f. Demonstrates maturity to take responsibility for own actions
5. *Integrity/Honesty: Chooses ethical courses of action*
   - a. Knows and demonstrates ability to distinguish between positive and negative behaviors
   - b. Demonstrates honesty and integrity in working with peers and supervisors
   - c. Takes full responsibility for personal actions
   - d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
   - e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
    - MFG-A1 through MFG-A4;
    - MFG-C1 through MFG-C10;
    - MFG-D1 through MFG-D5;
    - MFG-E1;
    - MFG-E3 through MFG-E5;
    - MFG-F2 through MFG-F8; and,
    - MFG-H1.
2. *Tool Design,* Donaldson, Lecain, and Gold, McGraw Hill Publishers, Latest Edition
3. *Technology of Machine Tools,* McGraw Hill Publishers, Latest Edition
4. *Machinery's Handbook,* Industrial Press, Latest Edition

MFG 216
01/011598

MFG 312

MASTER PROGRAM

Strength of Materials

COURSE SYLLABUS

Total lecture hours: 36 **Total lab hours: 36** **Credit hours: 4**

COURSE DESCRIPTION:

Demonstrates the relationships existing between externally applied forces and internally induced stresses, and the resulting deformations of structural members.

PREREQUISITES: Statics

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Determine internal stresses due to external loads;
2. Determine number of rivets required for a given load on a riveted joint;
3. Analyze a welded joint; and,
4. Determine the centroid and moment of inertia of a built-up section.

REQUIRED COURSE MATERIALS:

Textbook: *Applied Statics and Strength of Materials*, Spiegel and Limbunner, Merrill Publishers, Latest Edition

Lab Manual: NONE

Required Materials:

Engineering paper, green
Scientific Calculator

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Laboratory: Laboratory assignments will require student to solve appropriate problems involving the mechanical and physical properties of various materials.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments including writing assignments;
5. Contribute to class discussions; and,
6. Maintain attendance per current policy.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Centroids and Centers of Gravity	
(Review from CNC Machine Programming)	
Center of Gravity	
Centroids and Centroidal Axes	
Centroids and Centroidal Axes of Composite Areas	
Area Moments of Inertia	
Terms and Definitions	
Moments of Inertia	
The Transfer Formula	
Moments of Inertia of Composite Areas	
Radius of Gyration	
Polar Moment of Inertia	
Chapter Review	
Stresses and Strains	
Tensile and Compressive Stresses	
Shear Stresses	
Tensile and Compressive Strain and Deformation	
Shear Strain	
The Relationship Between Stress and Strain (Hooke's Law)	
Chapter Summary	
Torsion in Circular Sections	
Introduction	
Torsional Shear Stress	
Angle of Twist	
The Transmission of Power by Shafts	
Chapter Summary	
Shear and Bending Moments in Beams	
Types of Beams and Supports	
Types of Loads on Beams	

Beam Reactions
Shear Force and Bending Moments
Shear Diagrams
Moment Diagrams
Sections of Maximum Moment
Moving Loads
Chapter Summary
Stresses in Beams
Tensile and Compressive Stresses Due to Bending
The Flexure Formula
Computation of Bending Stresses
Shear Stresses
The General Shear Formula
Shear Stresses in Structural Members
Beam Analysis
Chapter Summary
Design of Beams
The Design Process
The Design of Steel Beams
The Design of Timber Beams
Chapter Summary
Review and Testing —

Total Lecture Hours 36

LAB OUTLINE:

Lab Topics	Contact Hrs.
Area Moments of Inertia	4
Stresses and Strains	8
Torsion in Circular Sections	8
Shear and Bending Moments in Beams	8
Stresses in Beams	4
Design of Beams	4
Total Lab Hours	36

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
  - *A. **Resources:** Identifies, organizes, plans, and allocates resources*
    1. Allocates time to complete assigned tasks on schedule
    2. Determines and allocates required materials and resources for meeting objectives
    3. Evaluates skills, performance, and quality of work and provides feedback
  - *B. **Interpersonal:** Works with others*
    1. Participates as a member of the team, contributing to group effort
    2. Provides individual assistance/direction to peers as requested
    3. Determines and meets expectations
    4. Exercises leadership qualities to effectively communicate ideas and make decisions.
    5. Negotiates resources in order to accomplish objectives
    6. Works well with all members of the class
  - *C. **Information:** Acquires and uses information*
    1. Acquires and evaluates information
    2. Organizes and maintains information
    3. Interprets and communicates information
  - *D. **Systems:** Understands complex inter-relationships*
    1. Understands and works well with social, organizational, and technological systems
    2. Monitors and corrects performance of system during operation
    3. Recommends modifications to system to improve performance
  - *E. **Technology:** Works with a variety of technologies*
    1. Chooses relevant procedures, tools, and equipment
    2. Applies appropriate procedures and techniques to accomplish tasks
    3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS
  - A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
    1. *__Reading:__ Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*

a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts

b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study

c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)

d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner

e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*

a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning

b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.

c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered

d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner

e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*

a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages

   b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
   c. Demonstrates ability to understand and perform multi-step computations
   d. Demonstrates ability to read, interpret, and use standard measuring devices
   e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
   f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
   g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines

4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
   a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
   b. Demonstrates ability to hear, comprehend, and appropriately follow directions
   c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
   d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
   e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
   f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed
5. *Speaking: Organizes ideas and communicates orally*
   a. Demonstrates appropriate listening and speaking skills in personal conversations
   b. Demonstrates ability to choose and organize appropriate words to effectively communicate
   c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
   d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
   e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups

- f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
- g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    - a. Demonstrates ability to objectively assess personal strengths and weaknesses
    - b. Demonstrates ability to set realistic short-term and long-term goals
    - c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
    - d. Demonstrates ability to identify potential pitfalls and take evasive actions
    - e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
    - f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
    - g. Demonstrates maturity in taking responsibility for decisions
2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    - a. Demonstrates ability to detect problem through observation, inquiry, or directive
    - b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    - c. Demonstrates ability to generate alternatives or options for problem solution
    - d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    - e. Demonstrates ability to initiate and effect solution
    - f. Demonstrates ability to take responsibility for outcomes
    - g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*

        - a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
        - b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
        - c. Demonstrates ability to visually discriminate in gross and fine imagery
        - d. Demonstrates ability to visualize abstractly
        - e. Demonstrates ability to apply visual imagery to applied tasks
    - *4.* ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
        - a. Demonstrates mastery of basic reading, math, and language skills through application
        - b. Demonstrates ability to translate abstract theory into practical application
        - c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
        - d. Demonstrates knowledge of good study skills and learning habits
    - *5.* ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
        - a. Demonstrates use of simple logic
        - b. Demonstrates ability to distinguish relationships
        - c. Demonstrates ability to determine and isolate factors in relationships
        - d. Demonstrates and applies knowledge through practice
        - e. Recognizes that attitudes, skills, and practice are essential to productivity
        - f. Demonstrates ability to discriminate between positive and negative, and act accordingly
- C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty
    - *1.* ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
        - a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
        - b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner

c. Demonstrates ability to focus on task at hand and work to completion

d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time

e. Demonstrates maturity to take responsibility for actions

f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*

a. Presents a positive attitude toward tasks

b. Demonstrates ability to separate work and personal behaviors

c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors

d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors

e. Demonstrates ability to accept and use constructive criticism

f. Accepts positive reinforcement in an appropriate manner

3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*

a. Demonstrates appropriate and acceptable social behaviors in interactions

b. Demonstrates ability to work cooperatively in individual, team, or group situations

c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner

d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly

4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*

a. Accepts personal strengths and weaknesses and uses the same for positive advancement

b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner

c. Demonstrates ability to formulate and follow personal schedules

d. Demonstrates ability to wisely use classroom time

e. Demonstrates use of good study habits and skills

    f. **Demonstrates maturity to take responsibility for own actions**

5. ***Integrity/Honesty:* *Chooses ethical courses of action***
    a. **Knows and demonstrates ability to distinguish between positive and negative behaviors**
    b. **Demonstrates honesty and integrity in working with peers and supervisors**
    c. **Takes full responsibility for personal actions**
    d. **Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable**
    e. **Demonstrates positive work and social ethics in undertakings**

Appropriate Reference Materials:

1. MASTER Technical Modules:
    MFG-A1 through MFG-A5;
    MFG-B1 through MFG-B3;
    MFG-B6;
    MFG-B13 through MFG-B15;
    MFG-C3; and,
    MFG-D1.
2. *Machinery's Handbook,* Industrial Press, Latest Edition
3. *Applied Statics and Strength of Materials,* Spiegel and Limbunner, Merrill Publishers, Latest Edition

PHYS 1310

MASTER PROGRAM

Fundamentals of Physics

COURSE SYLLABUS

Total lecture hours: 48 **Total lab hours: 0** **Credit hours: 3**

COURSE DESCRIPTION:

An algebra-level, problem–oriented course which presents special topics in classical physics, such as basic mechanics, optics, acoustics, or electricity.

PREREQUISITES: **Intermediate Algebra**

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:,

1. Demonstrate comprehension of ideas and concepts of physics of mechanics, energy, and motion;
2. Demonstrate the use of prerequisite mathematical skills and application of concepts in problem solving;
3. Apply problem solving techniques and quantitatively solve physics problems in topics of mechanics, energy; and,
4. Evaluate the assumptions and results of an analytically solved problem in terms of realistic expectations of experimental agreement.

RECOMMENDED COURSE MATERIALS:

Textbook: *Fundamentals of College Physics,* Nolan, Peter, J., W.C. Brown Publishers, Latest Edition

Supplies:
Scientific Calculator
Notebook paper
Metric ruler
Protractor (1 degree increments)
Graph paper
Pencils

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture and demonstrations.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete assignments;
2. Apply theory to assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments, including writing assignments and oral presentations;
5. Contribute to class discussions; and,
6. Maintain attendance per current policy; and,
7. Follow all rules and safety regulations.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Technical Mathematics and Measurement	4
A. Systems of Units and Measure	
B. Conversion of units and physical dimensions	
C. Significant figures and Scientific Notation	
D. Coordinate systems and Geometry review	
Forces and Vectors	6
A. Vector and scaler quantities	
B. Addition of vectors and resultant force	
C. Right Triangles and Sine, Cosine, and Tangent ratios	
D. Vector components and component addition	
Equilibrium and Friction	6
A. Newton's First and Third Laws of Motion	
B. Free-Body Diagrams	
C. Equilibrium of concurrent force systems	
D. Equilibrium and vector components	
E. Friction and Normal Force	
Torque and Rotational Equilibrium	5
A. Moment Arms	
B. Torque due to a force	
C. Resultant Torque and Rotational Equilibrium	
D. Center of Gravity	
Uniformly Accelerated Motion	5
A. Speed and Velocity	
B. Accelerated Motion	
C. Linear Equations and Motion	
D. Solution of accelerated problems	
E. Gravity and freely falling bodies	
Force and Acceleration	5

A. Newton's Second law of Motion	
B. Relationship between Weight and Mass	
C. Application of Newton's Second Law to Single Body Problems	
D. Problem Solving Techniques	
Energy and Momentum	6
A. Work and Resultant Work	
B. Work and Kinetic Energy	
C. Potential Energy	
D. Conservation of Energy	
E. Power	
F. Impulse and Momentum	
G. Law of Conservation of Momentum	
Rotational Motion	3
A. Motion in a Circular Path	
B. Centripetal Acceleration	
C. Centripetal Force	
D. Friction and the Centripetal Force	
Exams and Review	8
Total Lecture Hours	48

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
   - *A. Resources: Identifies, organizes, plans, and allocates resources*
      1. Allocates time to complete assigned tasks on schedule
      2. Determines and allocates required materials and resources for meeting objectives
      3. Evaluates skills, performance, and quality of work and provides feedback
   - *B. Interpersonal: Works with others*

1. Participates as a member of the team, contributing to group effort
2. Provides individual assistance/direction to peers as requested
3. Determines and meets expectations
4. Exercises leadership qualities to effectively communicate ideas and make decisions.
5. Negotiates resources in order to accomplish objectives
6. Works well with all members of the class

C. *Information: Acquires and uses information*
  1. Acquires and evaluates information
  2. Organizes and maintains information
  3. Interprets and communicates information

D. *Systems: Understands complex inter-relationships*
  1. Understands and works well with social, organizational, and technological systems
  2. Monitors and corrects performance of system during operation
  3. Recommends modifications to system to improve performance

E. *Technology: Works with a variety of technologies*
  1. Chooses relevant procedures, tools, and equipment
  2. Applies appropriate procedures and techniques to accomplish tasks
  3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
  1. ***Reading:** Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
    a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
    b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
    c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
    d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner

    e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
    a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
    b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
    c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
    d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
    e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments
3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
    b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
    c. Demonstrates ability to understand and perform multi-step computations
    d. Demonstrates ability to read, interpret, and use standard measuring devices
    e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
    f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
    g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines
4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*

  - a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
  - b. Demonstrates ability to hear, comprehend, and appropriately follow directions
  - c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
  - d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
  - e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
  - f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed

5. ***Speaking***: *Organizes ideas and communicates orally*
  - a. Demonstrates appropriate listening and speaking skills in personal conversations
  - b. Demonstrates ability to choose and organize appropriate words to effectively communicate
  - c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
  - d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
  - e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
  - f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
  - g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
  - a. Demonstrates ability to objectively assess personal strengths and weaknesses
  - b. Demonstrates ability to set realistic short-term and long-term goals
  - c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
  - d. Demonstrates ability to identify potential pitfalls and take evasive actions

    - e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
    - f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
    - g. Demonstrates maturity in taking responsibility for decisions

2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    - a. Demonstrates ability to detect problem through observation, inquiry, or directive
    - b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    - c. Demonstrates ability to generate alternatives or options for problem solution
    - d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    - e. Demonstrates ability to initiate and effect solution
    - f. Demonstrates ability to take responsibility for outcomes
    - g. Demonstrates ability to effectively problem solve in individual, team, or group situations

3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    - a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
    - b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
    - c. Demonstrates ability to visually discriminate in gross and fine imagery
    - d. Demonstrates ability to visualize abstractly
    - e. Demonstrates ability to apply visual imagery to applied tasks

4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    - a. Demonstrates mastery of basic reading, math, and language skills through application
    - b. Demonstrates ability to translate abstract theory into practical application

        c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
        d. Demonstrates knowledge of good study skills and learning habits
    5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
        a. Demonstrates use of simple logic
        b. Demonstrates ability to distinguish relationships
        c. Demonstrates ability to determine and isolate factors in relationships
        d. Demonstrates and applies knowledge through practice
        e. Recognizes that attitudes, skills, and practice are essential to productivity
        f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty
    1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
        a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
        b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
        c. Demonstrates ability to focus on task at hand and work to completion
        d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
        e. Demonstrates maturity to take responsibility for actions
        f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner
    2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
        a. Presents a positive attitude toward tasks
        b. Demonstrates ability to separate work and personal behaviors
        c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
        d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors

- e. Demonstrates ability to accept and use constructive criticism
- f. Accepts positive reinforcement in an appropriate manner

3. ***Sociability:** Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   - a. Demonstrates appropriate and acceptable social behaviors in interactions
   - b. Demonstrates ability to work cooperatively in individual, team, or group situations
   - c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
   - d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. ***Self-Management:** Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   - a. Accepts personal strengths and weaknesses and uses the same for positive advancement
   - b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   - c. Demonstrates ability to formulate and follow personal schedules
   - d. Demonstrates ability to wisely use classroom time
   - e. Demonstrates use of good study habits and skills
   - f. Demonstrates maturity to take responsibility for own actions
5. ***Integrity/Honesty:** Chooses ethical courses of action*
   - a. Knows and demonstrates ability to distinguish between positive and negative behaviors
   - b. Demonstrates honesty and integrity in working with peers and supervisors
   - c. Takes full responsibility for personal actions
   - d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
   - e. Demonstrates positive work and social ethics in undertakings

MASTER Curriculum
Manufacturing Technology
(Associate of Applied Science Degree Program)

		LEC	LAB	CR
First Quarter*				
PSYC 1100	College Success Skills	1	0	1
MFG 100	Machine Tool Practices I	3	9	6
DDT 104	Drafting Principles	2	4	3
MATH 1314	College Algebra	4	0	3
ENGL 1301	Composition I	4	0	3
		14	13	16
Second Quarter*				
MFG 200	Machine Tool Practices II	3	9	6
ENGL 134	Interpersonal Communication	4	0	3
MATH 1316	Plane Trigonometry	4	0	3
CNS 2060	Application Software	1	4	3
		12	13	15
Third Quarter*				
MFG 112	Engineering Materials	2	3	3
OSH 216	Safety and Accident Prevention	2	3	3
PHY 114	Fluid Power I	3	3	4
EST 120	Electrical Applications	3	3	4
WLT 105	Survey of Welding Processes & Applications	3	3	4
		13	15	18
Fourth Quarter*				
MFG 205	CNC Machine Programming	3	3	4
MFG 206	Statics	3	3	4
MFG 301	Manufacturing Processes	3	3	4
DDT 128	Introduction to Computer Drafting	1	4	2
PSYC 2301	General Psychology	4	0	3
		14	13	17
FIFTH QUARTER*				
MFG 302	CAD/CAM I	3	3	4
MFG 216	Tool Design I	2	6	4
MFG 312	Strength of Materials	3	3	4
PHYS 1310	Fundamentals of Physics	4	0	3
	Free Elective	2	0	2
		14	12	17
Sixth Quarter*				
MFG 318	CAD/CAM II	3	3	4
MFG 315	Computer Integrated Manufacturing	2	2	3
MFG 324	Quality Assurance & Statistical Process Control	2	3	3
MFG 322	Engineering Technology Project	4	6	6
		11	14	16
	Program Totals	78	80	99

Sixth Quarter

*** Each quarter is 12 weeks in length**

MASTER PROGRAM

CAD/CAM II

COURSE SYLLABUS

Total lecture hours: 36 **Total lab hours: 36** **Credit hours: 4**

COURSE DESCRIPTION:

Continues topics developed in MFG 302, CAD/CAM I, with advanced utilization of CAM software. Topics include the following: 3–D process modeling, creation and utilization of different work planes, 4th– and 5th–axis programming, creation of tool path for surface primitives, swept surfaces, translated surfaces, sculpted surfaces, ruled surfaces, and coons surfaces. Additional topics include: projecting, intersecting, blending, and trimming one surface to another surface. Students will program both a simple punch and die set and a simple injection mold cavity.

PREREQUISITES: CAD/CAM I

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Demonstrate the ability to work within the CAM 3–D menu tree;
2. Demonstrate the ability to both identify and create various surfaces which are available in the CAM 3–D system to include:
    a. surface primitives;
        (1) plane;
        (2) cone;
        (3) cylinder;
        (4) sphere;
        (5) toris;
    b. composite surfaces;
        (1) spun;
        (2) translated;
        (3) ruled;
        (4) lofted;
        (5) form patch;
3. Demonstrate the comprehension of Work Planes and Plane Coordinates and the ability to change from one work plane to another work plane;
4. Demonstrate the ability to construct surface boundaries;
5. Generate tool path in both the generator and radial directions;

6. Develop tool path geometry and part geometry to produce accurately coded information for 3–D CNC mill parts; and,
7. Demonstrate the 3–D technique of projection and intersection.

REQUIRED COURSE MATERIALS:

Textbook: *SMARTCAM-3D,* Pelton, TSTC Publication, Latest Edition
Lab Manual: NONE

Materials and/or Supplies: 2 - double sided, high density 3½" floppy diskettes

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, overheads and CAM and software demonstrations.

Laboratory: Laboratory will be hands–on (computer based) process modeling CAM System.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Demonstrate the comprehension of Work Plane and Plane Coordinates and the ability to change from one work plane to another work plane to perform work;
2. Demonstrate the ability to construct surface boundaries on various work planes;
3. Demonstrate the ability to both identify and create various surfaces which are available in the CAM 3-D system to include:
   Surface Primitives: Plane, Cone, Cylinder, Sphere, Toris;
   Composite Surfaces: Spun, Translated, Ruled, Lofted, Form Patch, Coons;
4. Generate tool path in both the generator, radial and planar directions;
5. Develop tool path geometry and part geometry to produce accurately coded information for 3-D CNC mill parts;
6. Demonstrate the 3-D techniques of projection, intersection, surface trim and blend;
7. Utilize plotters and printers to produce accurate documents;
8. Perform and demonstrate the ability to transfer CAD files to CAM files and CAM files to CAD files;
9. Generate a tool path from CAD to CAM files;
10. Edit a tool path from a CAD file and proof the tool path from a CAD file;
11. Satisfactorily perform on written, oral, and practical examinations;

12. Satisfactorily perform on outside assignments including writing assignments;
13. Contribute to class discussions; and,
14. Maintain attendance per current policy.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Understanding 3-D Parts	
Coordinate Systems in CAM's Advanced 3-D Machining	
Choosing Active Work Planes	
World vs. Local Coordinate Inputs	
Working with Geometry on Work Planes	
Planning and Creating the 3-D Model	
Surface Primitives	
Understanding Surfaces	
Types of Surfaces	
Plane	
Cone	
Cylinder	
Sphere	
Toris	
Composite Surfaces	
Spun Surfaces	
Translated Surfaces	
Ruled Surfaces	
Review for Quiz 1	
QUIZ 1	
Sculpted Surfaces	
Lofted Surfaces	
Form Patch Surfaces	
Coons Surfaces	
Modeling 3-D Surface Toolpaths	
Expert Tips for Model Construction	
Using Wireframe Geometry for Surface E Definition	
Creating 3-D Surface Tool Paths	
Creating a Blend Surface	
Planar Cuts	
Review for Quiz 2	
QUIZ 2	
Additional Modeling Practices	
Projection	
Intersection	
Surface Trim and Blend	
Editing Surfaces	

Review for Quiz 3
QUIZ 3

Total Lecture Hours 36

LAB OUTLINE:

Lab Topics	**Contact Hrs.**
Understanding Work Planes	2
Surface Primitives	3
Composites Surfaces	2
Sculpted Surfaces	2
Process Modeling (Drawing)	24
a. Wax Block	
b. Pyramid	
c. Palace	
d. Round Punch	
e. Ruled Block	
f. Cross	
g. Round Die	
h. Shift Boot	
i. Fin	
j. Knobmold	
Final Project	3
Total Lab Hours	36

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
   A. *Resources: Identifies, organizes, plans, and allocates resources*
      1. Allocates time to complete assigned tasks on schedule

    2. Determines and allocates required materials and resources for meeting objectives
    3. Evaluates skills, performance, and quality of work and provides feedback
- *B.* *Interpersonal: Works with others*
    1. Participates as a member of the team, contributing to group effort
    2. Provides individual assistance/direction to peers as requested
    3. Determines and meets expectations
    4. Exercises leadership qualities to effectively communicate ideas and make decisions.
    5. Negotiates resources in order to accomplish objectives
    6. Works well with all members of the class
- *C.* *Information: Acquires and uses information*
    1. Acquires and evaluates information
    2. Organizes and maintains information
    3. Interprets and communicates information
- *D.* *Systems: Understands complex inter-relationships*
    1. Understands and works well with social, organizational, and technological systems
    2. Monitors and corrects performance of system during operation
    3. Recommends modifications to system to improve performance
- *E.* *Technology: Works with a variety of technologies*
    1. Chooses relevant procedures, tools, and equipment
    2. Applies appropriate procedures and techniques to accomplish tasks
    3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

- **A.** **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
    - *1.* ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
        - a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
        - b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
        - c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts,

diagrams, graphs, schematics, blueprints, flow charts, etc.)

   d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner
   e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. ***Writing:** Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
   b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
   c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
   d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
   e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments
3. ***Arithmetic/Mathematics:** Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
   b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
   c. Demonstrates ability to understand and perform multi-step computations
   d. Demonstrates ability to read, interpret, and use standard measuring devices
   e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
   f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance

        - g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines
    - 4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
        - a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
        - b. Demonstrates ability to hear, comprehend, and appropriately follow directions
        - c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
        - d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
        - e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
        - f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed
    - 5. *Speaking: Organizes ideas and communicates orally*
        - a. Demonstrates appropriate listening and speaking skills in personal conversations
        - b. Demonstrates ability to choose and organize appropriate words to effectively communicate
        - c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
        - d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
        - e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
        - f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
        - g. Demonstrates ability to take responsibility for presentations
- B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons
    - 1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
        - a. Demonstrates ability to objectively assess personal strengths and weaknesses

b. Demonstrates ability to set realistic short-term and long-term goals
c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
d. Demonstrates ability to identify potential pitfalls and take evasive actions
e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
g. Demonstrates maturity in taking responsibility for decisions

2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
   a. Demonstrates ability to detect problem through observation, inquiry, or directive
   b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
   c. Demonstrates ability to generate alternatives or options for problem solution
   d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
   e. Demonstrates ability to initiate and effect solution
   f. Demonstrates ability to take responsibility for outcomes
   g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
   a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
   b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
   c. Demonstrates ability to visually discriminate in gross and fine imagery
   d. Demonstrates ability to visualize abstractly
   e. Demonstrates ability to apply visual imagery to applied tasks

4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. Demonstrates mastery of basic reading, math, and language skills through application
    b. Demonstrates ability to translate abstract theory into practical application
    c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
    d. Demonstrates knowledge of good study skills and learning habits
5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. Demonstrates use of simple logic
    b. Demonstrates ability to distinguish relationships
    c. Demonstrates ability to determine and isolate factors in relationships
    d. Demonstrates and applies knowledge through practice
    e. Recognizes that attitudes, skills, and practice are essential to productivity
    f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
    a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
    b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
    c. Demonstrates ability to focus on task at hand and work to completion
    d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
    e. Demonstrates maturity to take responsibility for actions
    f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner
2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
    a. Presents a positive attitude toward tasks

   b. Demonstrates ability to separate work and personal behaviors
   c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
   d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
   e. Demonstrates ability to accept and use constructive criticism
   f. Accepts positive reinforcement in an appropriate manner

3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   a. Demonstrates appropriate and acceptable social behaviors in interactions
   b. Demonstrates ability to work cooperatively in individual, team, or group situations
   c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
   d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly

4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   a. Accepts personal strengths and weaknesses and uses the same for positive advancement
   b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
   c. Demonstrates ability to formulate and follow personal schedules
   d. Demonstrates ability to wisely use classroom time
   e. Demonstrates use of good study habits and skills
   f. Demonstrates maturity to take responsibility for own actions

5. ***Integrity/Honesty:*** *Chooses ethical courses of action*
   a. Knows and demonstrates ability to distinguish between positive and negative behaviors
   b. Demonstrates honesty and integrity in working with peers and supervisors
   c. Takes full responsibility for personal actions
   d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
   e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
    - MFG-B1 through MFG-B3;
    - MFG-B6 through MFG-B8;
    - MFG-C1 through MFG-C8;
    - MFG-D2;
    - MFG-D6; and,
    - MFG-H1 through MFG-H5.
2. *SMARTCAM Advanced 3-D Machining Reference Manual*, Latest Edition
3. *Technology of Machine Tools*, McGraw Hill Publishers, Latest Edition
4. Machine Tool Catalogs

MASTER PROGRAM

Computer Integrated Manufacturing

COURSE SYLLABUS

Total lecture hours: 24 **Total lab hours: 24** **Credit hours: 3**

COURSE DESCRIPTION:

Introduces the fundamentals of Computer Integrated Manufacturing (CIM) including the key elements and technologies involved. Covers the typical applications which exist in industry today and the major trends affecting the future of manufacturing.

PREREQUISITES: NONE

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Demonstrate knowledge of fundamental CIM concepts to include present applications of CIM, and future applications for CIM technologies;
2. Demonstrate knowledge of application considerations for robotics including: robot safety, where to use robotics, robot mechanical configurations, robot power sources, Servo vs. Non-Servo robot control, economic factors, and robot specifications;
3. Demonstrate knowledge of computer fundamentals such as logging onto Local Area Networks, editing and saving ASCII text files, block diagrams of computer system hardware components, flow of information via a shared data busses, PC buss types and I/O card compatibility, board level assembly of Personal Computers;
4. Perform basic ASCII data file manipulation tasks including generation and editing of teat files for robot control, use of file processing utilities, and use of data communication software for RS-232 ASCII file transfers;
5. Write simple VAL and AML language robot programs for machine loading and assembly tasks including instructions for basic arm movements, speed control, program looping, decision making, and discrete Input/Output interfacing operations and test these programs for proper operation using a PUMA 562 industrial robot and IBM 7576 industrial robot, and a robot application simulator program;

6. Demonstrate a basic knowledge of relay control wiring schematics and programmable logic controllers and enter a simple ladder logic program into a PLC, and will check operation of the program with the CIM LAB conveyor or PLC I/O simulator;
7. Create a graphical CIM facilities layout, create a process configuration file and a compiled system control file capable of controlling the CIM laboratory equipment using the use process configuration module of the AMNET CIM software;
8. Demonstrate skills required to start up, operate, and shut down the basic equipment in the CIM laboratory using the task sheets developed for each piece of equipment;
9. Demonstrate a basic knowledge of RS-232 standard serial data communication including identification of DTE and DCE, hardware handshaking signals, and software date transfer/line settings; and,
10. Demonstrate a basic knowledge of DXF file transfer from CAD to CAM systems, and CAD drawing considerations that facilitate this transfer.

REQUIRED COURSE MATERIALS:

Textbook:	*Computer-Automated Manufacturing,* John H. Powers Jr., McGraw-Hill Publishers, Latest Edition
Lab Manual:	NONE

Hand Tools/Quantity Required:
Safety Glasses
6 inch Ruler
0-6 inch Dial Calipers
Pencil
Scientific Calculator
3½ high density disk

METHODS OF INSTRUCTION:

Lecture:	Didactic presentations will include lecture, video and demonstrations.
Laboratory:	Laboratory will be hands–on activities.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments including writing assignments;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all shop rules and safety regulations as stated in the laboratory manual.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to Computer–Automated Manufacturing	4
What is Computer–Automated Manufacturing	
Why Do We Use Computers in Manufacturing	
Computer Control	
Computer Applications in Manufacturing	
Trends in the Use of Computers in Manufacturing	
Computer Technologies	4
Computer Hardware	
Computer Software	
Micro and Minicomputers	
Artificial Intelligence	
Computer Automated Engineering	4
Computer Graphics Technology	
Computer Automated Design	
Computer Tools for Engineering Analysis	
Robotics	4
Basic Robotic Technology	
Intelligent Robotics Systems	
Robot Application	
Implementing Robotics in Manufacturing	
Manufacturing Systems	4
System Architecture	
Management Systems	
Integrated Manufacturing Systems	
Computer Automated Manufacturing	4
Automated Manufacturing	
Implementing CAM	—
Total Lecture Hours	**24**

LAB OUTLINE:

Lab Topics	Contact Hrs.
CIM Lab Safety	2
CIM System Components	6
a) Conveyor Systems	
b) Automated Storage and Retrieval Systems	
c) PUMA 562 Robot	
d) IBM 7576 Robot	
e) CNC Vertical Milling Center	
f) CNC Turning Center	
g) Vision Systems	
h) Barcode Systems	
CIM Software	4
Robot Programming	4
Programming CNC Machining Centers	4
Manufacturing Cells/System Integration	4
Total Lab Hours	24

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
  - *A. Resources: Identifies, organizes, plans, and allocates resources*
    1. Allocates time to complete assigned tasks on schedule
    2. Determines and allocates required materials and resources for meeting objectives
    3. Evaluates skills, performance, and quality of work and provides feedback
  - *B. Interpersonal: Works with others*
    1. Participates as a member of the team, contributing to group effort

2. Provides individual assistance/direction to peers as requested
3. Determines and meets expectations
4. Exercises leadership qualities to effectively communicate ideas and make decisions.
5. Negotiates resources in order to accomplish objectives
6. Works well with all members of the class

C. *Information: Acquires and uses information*
   1. Acquires and evaluates information
   2. Organizes and maintains information
   3. Interprets and communicates information

D. *Systems: Understands complex inter-relationships*
   1. Understands and works well with social, organizational, and technological systems
   2. Monitors and corrects performance of system during operation
   3. Recommends modifications to system to improve performance

E. *Technology: Works with a variety of technologies*
   1. Chooses relevant procedures, tools, and equipment
   2. Applies appropriate procedures and techniques to accomplish tasks
   3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
   1. *Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
      a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts
      b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study
      c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
      d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner

   e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning
   b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.
   c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered
   d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner
   e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments
3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages
   b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems
   c. Demonstrates ability to understand and perform multi-step computations
   d. Demonstrates ability to read, interpret, and use standard measuring devices
   e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
   f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
   g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines
4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*

- a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
- b. Demonstrates ability to hear, comprehend, and appropriately follow directions
- c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
- d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
- e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
- f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed

5. Speaking: Organizes ideas and communicates orally

- a. Demonstrates appropriate listening and speaking skills in personal conversations
- b. Demonstrates ability to choose and organize appropriate words to effectively communicate
- c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
- d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
- e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
- f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
- g. Demonstrates ability to take responsibility for presentations

B. Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative

- a. Demonstrates ability to objectively assess personal strengths and weaknesses
- b. Demonstrates ability to set realistic short-term and long-term goals
- c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
- d. Demonstrates ability to identify potential pitfalls and take evasive actions

   - e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
   - f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
   - g. Demonstrates maturity in taking responsibility for decisions

2. ***Problem Solving:** Recognizes problems and devises and implements plan of action*
   - a. Demonstrates ability to detect problem through observation, inquiry, or directive
   - b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
   - c. Demonstrates ability to generate alternatives or options for problem solution
   - d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
   - e. Demonstrates ability to initiate and effect solution
   - f. Demonstrates ability to take responsibility for outcomes
   - g. Demonstrates ability to effectively problem solve in individual, team, or group situations

3. ***Seeing Things In the Mind's Eye:** Organizes, and processes symbols, pictures, graphs, objects, and other information*
   - a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery
   - b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
   - c. Demonstrates ability to visually discriminate in gross and fine imagery
   - d. Demonstrates ability to visualize abstractly
   - e. Demonstrates ability to apply visual imagery to applied tasks

4. ***Knowing How to Learn:** Use efficient learning techniques to acquire and apply new knowledge and skills*
   - a. Demonstrates mastery of basic reading, math, and language skills through application
   - b. Demonstrates ability to translate abstract theory into practical application

        c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
        d. Demonstrates knowledge of good study skills and learning habits
    5. *Reasoning: Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
        a. Demonstrates use of simple logic
        b. Demonstrates ability to distinguish relationships
        c. Demonstrates ability to determine and isolate factors in relationships
        d. Demonstrates and applies knowledge through practice
        e. Recognizes that attitudes, skills, and practice are essential to productivity
        f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty
    1. *Responsibility: Exerts a high level of effort and perseveres towards goal attainment*
        a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
        b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
        c. Demonstrates ability to focus on task at hand and work to completion
        d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
        e. Demonstrates maturity to take responsibility for actions
        f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner
    2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
        a. Presents a positive attitude toward tasks
        b. Demonstrates ability to separate work and personal behaviors
        c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
        d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors

    - e. Demonstrates ability to accept and use constructive criticism
    - f. Accepts positive reinforcement in an appropriate manner

3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    - a. Demonstrates appropriate and acceptable social behaviors in interactions
    - b. Demonstrates ability to work cooperatively in individual, team, or group situations
    - c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
    - d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly

4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    - a. Accepts personal strengths and weaknesses and uses the same for positive advancement
    - b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
    - c. Demonstrates ability to formulate and follow personal schedules
    - d. Demonstrates ability to wisely use classroom time
    - e. Demonstrates use of good study habits and skills
    - f. Demonstrates maturity to take responsibility for own actions

5. *Integrity/Honesty: Chooses ethical courses of action*
    - a. Knows and demonstrates ability to distinguish between positive and negative behaviors
    - b. Demonstrates honesty and integrity in working with peers and supervisors
    - c. Takes full responsibility for personal actions
    - d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
    - e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
    MFG-A1 through MFG-A4;
    MFG-C7 through MFG-C8; and,

MFG-I1 through MFG-I4.

2. *Machinery's Handbook,* Industrial Press, Latest Edition
3. *Computer-Automated Manufacturing,* John H. Powers Jr., McGraw-Hill Publishers, Latest Edition

MFG 315
01/08/1997

MASTER PROGRAM

Quality Assurance and Statistical Process Control

COURSE SYLLABUS

Total lecture hours: 24 **Total lab hours: 36** **Credit hours: 3**

COURSE DESCRIPTION:

Introduces the concepts of applied quality control systems. Topics covered include quality responsibility, control chart methods, sampling techniques, reliability applications, and computer utilization/programs.

PREREQUISITES: NONE

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Understand the basics of statistical process control;
2. Apply either Deming's or Crosby's basic methods;
3. Utilize statistics to determine variations and develop attributes charts; and,
4. Solve problems in quality analysis.

REQUIRED COURSE MATERIALS:

Textbook: *Statistical Process Control and Quality Improvement,* Gerald Smith, Macmillan Publishers, Latest Edition

Lab Manual: *Quality Control Laboratory Manual,* TSTC Publication, Latest Edition

Hand Tools/Quantity Required:

- Safety Glasses
- 6 inch Ruler
- 0-6 inch Dial Calipers
- Pencil
- Scientific Calculator with statistical functions to solve for: means and standard deviation
- 3½" high density disk

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Laboratory: Laboratory will be hands–on activities.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments including writing assignments;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all shop rules and safety regulations as stated in the laboratory manual.

LECTURE OUTLINE:

Lecture Topics	Contact Hrs.
Introduction to Statistical Process Control	
Prevention vs. Detection	
SPC Goals	
Basic Tools of SPC	
Statistical Process Control Techniques	
The Problem–Solving Model for an Existing Process	
Designed Experiments	
What is Quality?	
Striving for Quality	
Management's Dilemma	
Leadership by Management	
Deming's Way	
Deming's 14 Points for Management	
Crosby's Approach	
A Comparison; Deming vs. Crosby	
Which Way to Top Quality?	
Avoid the Pitfalls in the Quest for Quality	
Total Quality Management	
Introduction to Variation an Statistics	
Measurement Concepts	
Special–Cause and Common–Cause Variation	

The Variation Concepts
Distributions and SPC Goals
Basic Algebraic Concepts
Basic Statistical Concepts
Introduction to The Control Chart Concept
Variables and Attributes
Preparation for Control Charting
The General Procedure for an X-Bar and R Chart
The Normal Probability Distribution
The Frequency Distribution
Histograms
Probability Distribution
The Normal Distribution
Variable Control Charts
X–bar and R Charts
The Capability Analysis
The Median and Range Charts
X–Bar and S Charts
Variables Charts for Limited Data
Precontrol or Rainbow Charts
Compound Probability
Modified Precontrol for Tight Control
Charts for Individual Measurements
The Modified X–Bar and R Chart for Small Sets of Data
The Nominal X–Bar and R Chart
The Transformation X–Bar and R Chart
Attributes Control Charts
The Four Types of Attributes Charts
The P Chart
The NP Chart
The C Chart
The U Chart
SPC Applied to the Learning Process
Interpreting Control Chart
The Random Distribution of Points
Freaks
Binomial Distribution Applications
Freak Patterns
Shifts
Runs and Trends
Cycles
Grouping
Problem Solving
The Problem–Solving Sequence
Teamwork and Tools for Problem Solving

Brainstorming
Flowcharts
Story Boards
The Cause–and–Effect Diagram
Pareto Charts
Other Graphs for Problem Solving
Acceptance Sampling
The Sampling Dilemma
Random Sampling
Operating Characteristic Curve
The Average Outgoing Quality Curve
MLT_STD_105D for Inspection by Attributes
The Average Proportion Defective
Vendor Certification and Control Chart Monitoring —

Total Lecture Hours 24

LAB OUTLINE:

Lab Topics	Contact Hrs.
Introduction to SPC	3
Variations, Statistics and Histograms	3
Introduction to Control Charts	3
Probability Distribution	3
Variables Control Charts	3
Precontrol Charts	3
Attribute Control Charts	3
Interpreting Control Charts	3
Problem Solving	3
Acceptance Sampling	3
Total Lab Hours	**36**

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools: A SCANS Report for America 2000."

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

- A. *Resources: Identifies, organizes, plans, and allocates resources*
    1. Allocates time to complete assigned tasks on schedule
    2. Determines and allocates required materials and resources for meeting objectives
    3. Evaluates skills, performance, and quality of work and provides feedback
- B. *Interpersonal: Works with others*
    1. Participates as a member of the team, contributing to group effort
    2. Provides individual assistance/direction to peers as requested
    3. Determines and meets expectations
    4. Exercises leadership qualities to effectively communicate ideas and make decisions.
    5. Negotiates resources in order to accomplish objectives
    6. Works well with all members of the class
- C. *Information: Acquires and uses information*
    1. Acquires and evaluates information
    2. Organizes and maintains information
    3. Interprets and communicates information
- D. *Systems: Understands complex inter-relationships*
    1. Understands and works well with social, organizational, and technological systems
    2. Monitors and corrects performance of system during operation
    3. Recommends modifications to system to improve performance
- E. *Technology: Works with a variety of technologies*
    1. Chooses relevant procedures, tools, and equipment
    2. Applies appropriate procedures and techniques to accomplish tasks
    3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

- A. **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
    1. *Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
        - a. Demonstrates basic reading skills including abilities to perceive main ideas, draw appropriate conclusions, detect a sequence, locate answers, find facts, and infer from written texts

b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information from text and supplemental materials on a level to facilitate productive independent and group study

c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)

d. Demonstrates ability to read, interpret, and follow schedules and procedural instructions in a timely and appropriate manner

e. Demonstrates ability to choose and use most appropriate reading method (skim, scan, or read for comprehension) for materials

2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*

   a. Demonstrates basic writing skills including abilities to produce written documents which conform with accepted grammatical and communication standards required for effective daily functioning

   b. Demonstrates effective written study skills including note taking, maintaining course specific journals, workbooks, manuals, etc.

   c. Demonstrates technical writing skills in preparing outlines, summaries, time lines, flow charts, diagrams, etc. appropriate to materials covered

   d. Demonstrates ability to complete all required writings in a timely, complete, and professional manner

   e. Demonstrates competence in subject matter through the organization and presentation of answers to required written assessments

3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*

   a. Demonstrates proficiency in basic arithmetic functions including ability to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages

   b. Demonstrates ability to read, comprehend, and select appropriate math procedures to work basic math problems

   c. Demonstrates ability to understand and perform multi-step computations

   - d. Demonstrates ability to read, interpret, and use standard measuring devices
   - e. Demonstrates ability to comprehend, retain, and utilize course specific measuring devices effectively
   - f. Demonstrates ability to understand, retain, and utilize higher mathematical formulas and functions required for course specific math performance
   - g. Demonstrates ability to appropriately transfer mathematical calculations and information from paper to machines

4. ***Listening:* *Receives, attends to, interprets, and responds to verbal messages and other cues***
   - a. Functions at minimal or above required hearing levels to receive, attend, interpret, and respond to verbal messages and instructions and to safely operate machinery
   - b. Demonstrates ability to hear, comprehend, and appropriately follow directions
   - c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
   - d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
   - e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
   - f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed

5. ***Speaking*: *Organizes ideas and communicates orally***
   - a. Demonstrates appropriate listening and speaking skills in personal conversations
   - b. Demonstrates ability to choose and organize appropriate words to effectively communicate
   - c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
   - d. Demonstrates ability to spontaneously organize and present appropriate answers and/or short presentations for classroom and /or assessment purposes
   - e. Demonstrates ability to formulate, organize, and deliver major presentations to peers or groups
   - f. Demonstrates ability to speak effectively in one-on-one, small group, or large group presentations
   - g. Demonstrates ability to take responsibility for presentations

B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    - a. Demonstrates ability to objectively assess personal strengths and weaknesses
    - b. Demonstrates ability to set realistic short-term and long-term goals
    - c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
    - d. Demonstrates ability to identify potential pitfalls and take evasive actions
    - e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
    - f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
    - g. Demonstrates maturity in taking responsibility for decisions
2. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    - a. Demonstrates ability to detect problem through observation, inquiry, or directive
    - b. Demonstrates ability to grasp appropriate overview and degree of seriousness of problem and to behave responsibly in situation
    - c. Demonstrates ability to generate alternatives or options for problem solution
    - d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
    - e. Demonstrates ability to initiate and effect solution
    - f. Demonstrates ability to take responsibility for outcomes
    - g. Demonstrates ability to effectively problem solve in individual, team, or group situations
3. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    - a. Functions at minimum or above required visual levels in order to see, interpret, attend and respond to visual imagery and meet safety requirements for necessary machinery

- b. Demonstrates ability to read, interpret, and act upon signs, symbols, and other visual cues
- c. Demonstrates ability to visually discriminate in gross and fine imagery
- d. Demonstrates ability to visualize abstractly
- e. Demonstrates ability to apply visual imagery to applied tasks

4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
   - a. Demonstrates mastery of basic reading, math, and language skills through application
   - b. Demonstrates ability to translate abstract theory into practical application
   - c. Demonstrates ability to incorporate and generalize new learning into a sequential learning process
   - d. Demonstrates knowledge of good study skills and learning habits
5. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   - a. Demonstrates use of simple logic
   - b. Demonstrates ability to distinguish relationships
   - c. Demonstrates ability to determine and isolate factors in relationships
   - d. Demonstrates and applies knowledge through practice
   - e. Recognizes that attitudes, skills, and practice are essential to productivity
   - f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
   - a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
   - b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
   - c. Demonstrates ability to focus on task at hand and work to completion
   - d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time

e. Demonstrates maturity to take responsibility for actions
f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
    a. Presents a positive attitude toward tasks
    b. Demonstrates ability to separate work and personal behaviors
    c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
    d. Demonstrates ability to accept personal strengths and weaknesses and builds on positive behaviors
    e. Demonstrates ability to accept and use constructive criticism
    f. Accepts positive reinforcement in an appropriate manner
3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. Demonstrates appropriate and acceptable social behaviors in interactions
    b. Demonstrates ability to work cooperatively in individual, team, or group situations
    c. Demonstrates active interest in peers by offering assistance, sharing resources, and sharing knowledge in a professional and acceptable manner
    d. Demonstrates professional work ethic by separating work and personal social behaviors and acting accordingly
4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. Accepts personal strengths and weaknesses and uses the same for positive advancement
    b. Demonstrates ability to continuously set, assess, choose, and modify objectives as the situation demands in an appropriate manner
    c. Demonstrates ability to formulate and follow personal schedules
    d. Demonstrates ability to wisely use classroom time
    e. Demonstrates use of good study habits and skills
    f. Demonstrates maturity to take responsibility for own actions
5. ***Integrity/Honesty:*** *Chooses ethical courses of action*
    a. Knows and demonstrates ability to distinguish between positive and negative behaviors

b. Demonstrates honesty and integrity in working with peers and supervisors
c. Takes full responsibility for personal actions
d. Demonstrates understanding of consequences for negative ethical behaviors and accepts responsibility for same when applicable
e. Demonstrates positive work and social ethics in undertakings

Appropriate Reference Materials:

1. MASTER Technical Modules:
    MFG-A1 through MFG-A4;
    MFG-B1 through MFG-B4;
    MFG-B6;
    MFG-B13;
    MFG-C1 through MFG-C3;
    MFG-C5 through MFG-C8;
    MFG-C10;
    MFG-D1;
    MFG-E1;
    MFG-E3 through MFG-E5;
    MFG-I1 through MFG-I3; and,
    MFG-J1 through MFG-J3.
2. *Machinery's Handbook,* Industrial Press, Latest Edition
3. *Statistical Process Control and Quality Improvement,* by Gerald Smith, Macmillan Publishing Company, Latest Edition

MFG 322

MASTER PROGRAM

Engineering Technology Project

COURSE SYLLABUS

Total lecture hours: 48 **Total lab hours: 72** **Credit hours: 6**

COURSE DESCRIPTION:

Assigns to students, utilizing team concepts, different industrial level projects emphasizing manufacturing applications/research in the areas of CNC, CAD/CAM, CIM, or plastics.

PREREQUISITES: CAD/CAM I;
Strength of Materials

COURSE OBJECTIVES:

After successful completion of this course, the students will be able to:

1. Complete an engineering project as part of a team;
2. Implement the team approach to problem solving; and,
3. Work with teammates intensively for extended periods of time.

REQUIRED COURSE MATERIALS:

Textbook: NONE
Lab Manual: NONE

Hand Tools/Quantity Required: See basic tool list for Machine Tool Practices I

METHODS OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, video and demonstrations.

Laboratory: Laboratory will be hands–on manufacturing assignments which will require the use of problem solving skills by the students.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. Perform the manipulative skills of the craft as required to satisfactorily complete laboratory assignments;
2. Apply theory to laboratory assignments;
3. Satisfactorily perform on written, oral, and practical examinations;
4. Satisfactorily perform on outside assignments including writing assignments;
5. Contribute to class discussions;
6. Maintain attendance per current policy; and,
7. Follow all shop rules and safety regulations as stated in the laboratory manual.

LECTURE OUTLINE:

Lecture content will be determined by the instructor based on the manufacturing–related exercise(s) which have been selected for the students.

Total Lecture Hours 48

LAB OUTLINE:

Lab activities will be determined by the instructor based on the manufacturing–related exercise(s) which have been selected for the students.

Total Lab Hours 72

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. All italicized headings in this section are direct quotations from "What Work Requires of Schools:-A SCANS Report for America 2000."

***** ***This course can be considered to be scans intensive due to the nature and structure of the course.***

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

- **A.** ***Resources:*** *Identifies, organizes, plans, and allocates resources*
  1. Allocates time to complete assigned tasks on schedule
  2. Determines and allocates required materials and resources for meeting objectives
  3. Evaluates skills, performance, and quality of work and provides feedback
- **B.** ***Interpersonal:*** *Works with others*
  1. Participates as a member of the team, contributing to group effort
  2. Provides individual assistance/direction to peers as requested
  3. Determines and meets expectations
  4. Exercises leadership qualities to effectively communicate ideas and make decisions.
  5. Negotiates resources in order to accomplish objectives
  6. Works well with all members of the class
- **C.** ***Information:*** *Acquires and uses information*
  1. Acquires and evaluates information
  2. Organizes and maintains information
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- **D.** ***Systems:*** *Understands complex inter-relationships*
  1. Understands and works well with social, organizational, and technological systems
  2. Monitors and corrects performance of system during operation
  3. Recommends modifications to system to improve performance
- **E.** ***Technology:*** *Works with a variety of technologies*
  1. Chooses relevant procedures, tools, and equipment
  2. Applies appropriate procedures and techniques to accomplish tasks
  3. Identifies or solves problems to maintain equipment

II. FOUNDATION SKILLS

- **A.** **Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks
  - *1.* ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
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    - b. Demonstrates course specific reading skills including abilities to read, interpret, and comprehend information

    from text and supplemental materials on a level to facilitate productive independent and group study
    c. Demonstrates ability to read, interpret, and utilize information from course specific instruments (i.e., charts, diagrams, graphs, schematics, blueprints, flow charts, etc.)
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    c. Demonstrates ability to understand and perform multi-step computations
    d. Demonstrates ability to read, interpret, and use standard measuring devices

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        c. Demonstrates auditory ability to hear, comprehend, and utilize verbal classroom as well as other auditory instruction
        d. Demonstrates ability to discriminate between essential and non-essential verbal information and react appropriately
        e. Demonstrates ability to focus and fine-tune listening skills to receive, interpret, and respond to various sounds
        f. Demonstrates ability and maturity to seek and receive additional individualized instruction as needed
    5. ***Speaking**: Organizes ideas and communicates orally*
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        b. Demonstrates ability to choose and organize appropriate words to effectively communicate
        c. Demonstrates ability to speak clearly and distinctly with appropriate volume, tone, and body language for situation
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B. **Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons

1. ***Decision Making:** Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    a. Demonstrates ability to objectively assess personal strengths and weaknesses
    b. Demonstrates ability to set realistic short-term and long-term goals
    c. Demonstrates ability to recognize and distinguish between positive and negative alternatives
    d. Demonstrates ability to identify potential pitfalls and take evasive actions
    e. Demonstrates ability to objectively and responsibly evaluate alternatives by testing hypotheses and selecting most appropriate response
    f. Demonstrates ability to profit from negative evaluations or mistakes by reformulating, redirecting, reconstructing, or retesting alternatives
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    d. Demonstrates ability to research options, assess and evaluate options, and determine appropriate and best solution
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   - c. Demonstrates ability to visually discriminate in gross and fine imagery
   - d. Demonstrates ability to visualize abstractly
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- 4. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
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   - f. Demonstrates ability to discriminate between positive and negative, and act accordingly

C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

- 1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
   - a. Demonstrates ability to formulate realistic and useful short and long term goals and complete steps necessary to timely achieve goals
   - b. Demonstrates ability to make adjustments, revisions, and changes to achieve goals in a cooperative and polite manner
   - c. Demonstrates ability to focus on task at hand and work to completion
   - d. Demonstrates good work ethics through regular attendance, adequate classroom preparations, and appropriate use of classroom time
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   - f. Demonstrates ability to cooperatively work in individual, team, and group situations in timely and effective manner

2. ***Self-Esteem:** Believes in own self-worth and maintains a positive view of self*
   - a. Presents a positive attitude toward tasks
   - b. Demonstrates ability to separate work and personal behaviors
   - c. Actively participates in learning opportunities by sharing knowledge and skills with peers and instructors
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   - e. Demonstrates use of good study habits and skills
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   - b. Demonstrates honesty and integrity in working with peers and supervisors

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e. Demonstrates positive work and social ethics in undertakings

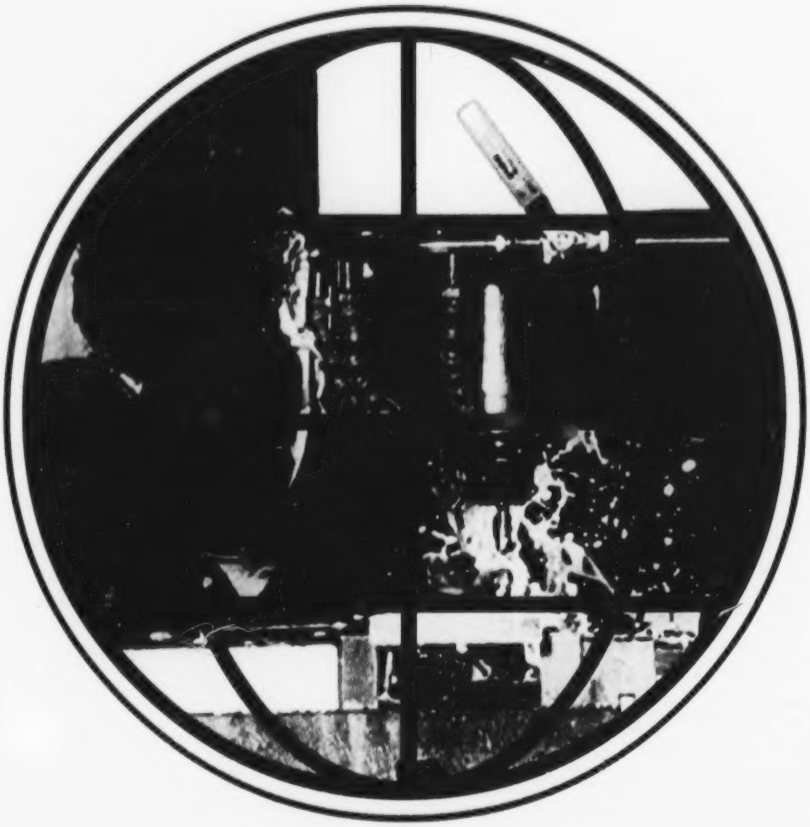
MFG 322
01/050997

MACHINE TOOL ADVANCED SKILLS TECHNOLOGY EDUCATIONAL RESOURCES

MASTER

a consortium of educators and industry

EDUCATIONAL RESOURCES
FOR THE
MACHINE TOOL INDUSTRY



Manufacturing Technology Series

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Supported by the National Science Foundation's Advanced Technological Education Program

MACHINE TOOL ADVANCED SKILLS TECHNOLOGY EDUCATIONAL RESOURCES

MASTER

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EDUCATIONAL RESOURCES
FOR THE
MACHINE TOOL INDUSTRY

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National Science Foundation
Advanced Technological
Education Program

"Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Foundation."

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National Science Foundation - Division of Undergraduate Education
MASTER Consortia of Employers and Educators

MASTER has built upon the foundation which was laid by the Machine Tool Advanced Skills Technology (MAST) Program. The MAST Program was supported by the U.S. Department of Education - Office of Vocational and Adult Education. Without this prior support MASTER could not have reached the level of quality and quantity that is contained in these project deliverables.

MASTER DEVELOPMENT CENTERS

Augusta Technical Institute - Central Florida Community College - Itawamba Community College - Moraine Valley Community College - San Diego City College (CACT) - Springfield Technical Community College - Texas State Technical College

INDUSTRIES

AB Lasers - AIRCAP/MTD - ALCOA - American Saw - AMOCO Performance Products - Automatic Switch Company - Bell Helicopter - Bowen Tool - Brunner - Chrysler Corp. - Chrysler Technologies - Conveyor Plus - Darr Caterpillar - Davis Technologies - Delta International - Devon - D. J. Plastics - Eaton Leonard - EBTEC - Electro-Motive - Emergency One - Eureka - Foster Mold - GeoDiamond/Smith International - Greenfield Industries - Hunter Douglas - Industrial Laser - ITT Engineered Valve - Kaiser Aluminum - Krueger International. - Laser Fare - Laser Services - Lockheed Martin - McDonnell Douglas - Mercury Tool - NASSCO - NutraSweet - Rapistan DEMAG - Reed Tool - ROHR, International - Searle - Solar Turbine - Southwest Fabricators - Smith & Wesson - Standard Refrigeration - Super Sagless - Taylor Guitars - Tecumseh - Teledyne Ryan - Thermal Ceramics - Thomas Lighting - FMC, United Defense - United Technologies Hamilton Standard

COLLEGE AFFILIATES

Aiken Technical College - Bevil Center for Advanced Manufacturing Technology - Chicago Manufacturing Technology Extension Center - Great Lakes Manufacturing Technology Center - Indiana Vocational Technical College - Milwaukee Area Technical College - Okaloosa-Walton Community College - Piedmont Technical College - Pueblo Community College - Salt Lake Community College - Spokane Community College - Texas State Technical Colleges at Harlington, Marshall, Sweetwater

FEDERAL LABS

Jet Propulsion Lab - Lawrence Livermore National Laboratory - L.B.J. Space Center (NASA) - Los Alamos Laboratory - Oak Ridge National Laboratory - Sandia National Laboratory - Several National Institute of Standards and Technology Centers (NIST) - Tank Automotive Research and Development Center (TARDEC) - Wright Laboratories

SECONDARY SCHOOLS

Aiken Career Center - Chicopee Comprehensive High School - Community High School (Moraine, IL) - Connally ISD - Consolidated High School - Evans High - Greenwood Vocational School - Hoover Sr. High - Killeen ISD - LaVega ISD - Lincoln Sr. High - Marlin ISD - Midway ISD - Moraine Area Career Center - Morse Sr. High - Point Lamar Sr. High -

Pontotoc Ridge Area Vocational Center - Putnam Vocational High School - San Diego Sr. High - Tupelo-Lee Vocational Center - Waco ISD - Westfield Vocational High School

ASSOCIATIONS

American Vocational Association (AVA) - Center for Occupational Research and Development (CORD) - CIM in Higher Education (CIMHE) - Heart of Texas Tech-Prep - Midwest (Michigan) Manufacturing Technology Center (MMTC) - National Coalition For Advanced Manufacturing (NACFAM) - National Coalition of Advanced Technology Centers (NCATC) - National Skills Standards Pilot Programs - National Tooling and Machining Association (NTMA) - New York Manufacturing Extension Partnership (NYMEP) - Precision Metalforming Association (PMA) - Society of Manufacturing Engineers (SME) - Southeast Manufacturing Technology Center (SMTC)

MASTER PROJECT EVALUATORS

Dr. James Hales, East Tennessee State University and William Ruxton, formerly with the National Tooling and Machine Association (NTMA)

NATIONAL ADVISORY COUNCIL MEMBERS

The National Advisory Council has provided input and guidance into the project since the beginning. Without their contributions, MASTER could not have been nearly as successful as it has been. Much appreciation and thanks go to each of the members of this committee from the project team.

Dr. Hugh Rogers-Dean of Technology-Central Florida Community College
Dr. Don Clark-Professor Emeritus-Texas A&M University
Dr. Don Edwards-Department of Management-Baylor University
Dr. Jon Botsford-Vice President for Technology-Pueblo Community College
Mr. Robert Swanson-Administrator of Human Resources-Bell Helicopter, TEXTRON
Mr. Jack Peck-Vice President of Manufacturing-Mercury Tool & Die
Mr. Don Hancock-Superintendent-Connally ISD

SPECIAL RECOGNITION

Dr. Hugh Rogers recognized the need for this project, developed the baseline concepts and methodology, and pulled together industrial and academic partners from across the nation into a solid consortium. Special thanks and singular congratulations go to Dr. Rogers for his extraordinary efforts in this endeavor.

Dr. Don Pierson served as the Principal Investigator for the first two years of MASTER. His input and guidance of the project during the formative years was of tremendous value to the project team. Special thanks and best wishes go to Dr. Pierson during his retirement and all his worldly travels.

All findings and deliverables resulting from MASTER are primarily based upon information provided by the above companies, schools and labs. We sincerely thank key personnel within these organizations for their commitment and dedication to this project. Including the national survey, more than 2,800 other companies and organizations participated in this project. We commend their efforts in our combined attempt to reach some common ground in precision manufacturing skills standards and curriculum development.

MASTER DEVELOPMENT CENTER
Texas State Technical College

Texas State Technical College System
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Manufacturing in Texas

Economic trends have led Texas officials to recognize the need to better prepare workers for a changing labor market. The downturn in the oil, natural gas, ranching and farming industries during the last decade diminished the supply of high-paying, low-skill jobs. Growth in Texas is occurring in the low paying, low skills service industry and in the high skills, high paying precision manufacturing industry. In Texas, projected increases by the year 2000 include 4,050 jobs for machine mechanics (24% growth rate); 4,700 jobs for machinists (18% growth rate); 3,850 numeric control operators (20% growth rate); and 107,150 general maintenance repair technicians (23% growth rate). The National Center for Manufacturing Sciences (NCMS) identified that of the top twenty manufacturing states, Texas experienced the largest increase in manufacturing employment. Manufacturing will add over 70,000 additional jobs in Texas by the year 2000 with increases in both durable and non-durable goods.

Texas State Technical College (TSTC)

Texas State Technical College System (TSTC) is authorized to serve the State of Texas through excellence in instruction, public service, research, and economic development. The system's efforts to improve the competitiveness of Texas business and industry include centers of excellence in technical program clusters on the system's campuses and support of educational research commercialization initiatives. Through close collaboration with business, industry, governmental agencies, and communities, including public and private secondary and postsecondary educational institutions, the system provides an articulated and responsive technical education system.

In developing and offering highly specialized technical programs and related courses, the TSTC system emphasizes the industrial and technological manpower needs of the state. Texas State Technical College is known for its advanced or emerging technical programs not commonly offered by community colleges.

New, high performance manufacturing firms in areas such as plastics, semiconductors and aerospace have driven dynamic change in TSTC's curriculum. Conventional metal fabrication to support oil and heavy manufacturing remains a cornerstone of the Waco campus and is a primary reason TSTC took the lead in developing new curricula for machining and manufacturing engineering technology in the MAST program.

Development Team

- **Principal Investigator**: Wallace Pelton served as the primary administrator and academic coordinator for the MASTER project.
- **Subject Matter/Curriculum Expert**: Steven Betros, Site Coordinator, was responsible for developing skill standards and course/program materials for the conventional machining, mold making and manufacturing engineering technology components of the MASTER project.

Introduction:
INSTRUCTOR'S HANDBOOK

Prior to the development of this Instructor's Handbook, **MASTER** project staff visited over 150 companies, conducted interviews with over 500 expert workers, and analyzed data from a national survey involving over 2800 participating companies. These investigations led to the development of a series of Instructor Handbooks, with each being fully industry-driven and specific to one of the technologies shown below.

Advanced CNC and CAM
Automated Equipment Repair
Computer Aided Design & Drafting
Conventional Machining
Industrial Maintenance
Instrumentation
LASER Machining
Manufacturing Technology
Mold Making
Tool And Die
Welding

Each Instructor's Handbook contains a collection of Technical Training Modules which are built around a Competency Profile for the specific occupation. **The Competency Profile which is the basis for this Instructor's Handbook, may be found on the following page (and on each of the tab pages of this book).**

Each Technical Training Module has been designed to be:

* Based on skill standards specified by industry. There must be a direct correlation between what industry needs and what is taught in the classroom and in the laboratory. For many years this type of training has been known as "competency-based training".

* Generic in nature. The training materials may then be customized by the trainer, for any given training situation based on the training need.

* Modular in design, to allow trainers to select lessons which are applicable to their training needs.

* Comprehensive, include training for advanced and emerging, highly-specialized manufacturing technologies.

- Self-contained, including all the components which might be needed by an experienced trainer. These components might include any or all of the following:
    - a standardized lesson plan,
    - an assessment instrument,
    - a listing of commercially available resources (e.g. recommended textbooks, instructor guides, student manuals, and videos),
    - new training materials, when suitable existing materials are not available (e.g., classroom handouts, transparency masters, and laboratory exercises).

This Instructor's Handbook is arranged by Duty groupings (Duty A, Duty B, etc.) with technical modules developed for each Task Box on the Competency Profile. Trainers are free to choose modules for a specific training need and combine modules to build individualized training programs.

This Instructor's Handbook is being offered with an accompanying Student Laboratory Manual for use by the students enrolled in the training program.

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/decimals	B-3 Convert Metric/English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
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J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MFG-A1

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-A1

Subject: **Manufacturing Technology** **Time: 2 Hrs.**

Duty: **Practice Safety**
Task: Follow Safety Manuals and All Safety Regulations/ Requirements

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Objective(s):

Upon completion of this unit the student will be able to:

a. Assume responsibility for the personal safety of oneself and others;
b. Develop a personal attitude towards safety;
c. Interpret safety manual directives;
d. Identify and control common machine shop hazards; and,
e. Comply with established company safety practices.

Instructional Materials:

MASTER Handout (MFG-A1-HO)
MASTER Laboratory Exercise (MFG-A1-LE)
MASTER Laboratory Aid (MFG-A1-LA)
MASTER Self-Assessment

References:

Specific Company Safety Policy and Procedures Manual
OSHA General Industry Requirements, U. S. Government Printing Office, Latest Edition

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Student Preparation:

All students must prepare themselves to enhance their attitudes toward safety. Such preparation may begin by the students asking themselves the following basic questions daily:

1. Is my hair properly stowed to prevent accidents?
2. Am I wearing any jewelry?
3. Do I have the proper shoes?
4. Do I have my eye shields (safety glasses)?
5. Is my work area free of debris and clean?
6. Does my machine have all its safeguards?
7. Is my machine working properly?
8. Do I know where the nearest fire extinguisher is?

Introduction:

Safety on the job is not only the responsibility of the management of the company. While management must establish rules according to regulations that the government has set forth for your industry, and while they must enforce these rules, every employee must be taught what these rules are and how to obey them. However, the responsibility for safety is in your hands. You are the person closest to the work being performed. Learn and follow all rules. Never take short cuts or chances. Make safety your way of life.

Presentation Outline:

- I. Assume Responsibility for the Personal Safety of Oneself and Others
  - A. Safety is a way of life not an option
  - B. Always operate with alertness and safety foremost in mind
- II. Develop a Personal Attitude Towards Safety
  - A. The key to safety is individual safety
  - B. Everyone must develop a safe attitude
  - C. Each step of the operation must be carefully planned
- III. Interpret Safety Manual Directives
  - A. Read and understand safety manual
  - B. Read machine operation instructions
- IV. Comply with Established Safety Practices
  - A. Personal safety
    - 1. Body: keep body out of line of tool edge
    - 2. Proper lifting technique
      - a. Personal lifting
        - 1) Lift with the legs, not the back
        - 2) Proper physical position while lifting
        - 3) Proper clearance for carrying
        - 4) "Buddy system" for heavy lifting
      - b. Equipment lifting
        - 1) Checking ratings for lifting devices
        - 2) Checking lifting points on lifted item
        - 3) Overhead clearance requirements
        - 4) Static lifting devices (slings, jack stands) should be used instead of moving lifting devices (jacks or forklifts) for actually holding heavy items up while working on them
  - B. Eyes: always wear safety glasses
  - C. Head: keep long hair up; wear hard hat whenever required
  - D. Ears: wear protection to prevent damage from noise
  - E. Jewelry: no rings, watches, bracelets, necklaces (they can get caught in machinery and they are conductors of electricity)

   - F. Clothing: keep sleeves and pant legs rolled down; and ties, strings, and belts away from moving parts
   - G. No horse-play
   - H. Do not talk to someone while that person is operating a machine
   - I. Do not talk to someone while you are operating a machine
- V. Identify and Control Common Machine Shop Hazards
   - A. Chip formation
   - B. Moving machine parts
   - C. Spills and other debris
   - D. Electrical lines
   - E. Hydraulic and pneumatic lines
- VI. Cover specific safety policies of the company

Practical Application:

The students must demonstrate a practical and aware attitude toward safety in the workplace at all times. No careless or unsafe behavior is acceptable.

NB: The laboratory exercise for this module is to be completed *before* the instruction begins. Laboratory Exercise MFG-A1-LE ties directly to the final laboratory exercise in the MFG-A Safety series.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-A2) dealing with the use of protective equipment.

MFG-A1-HO
Follow Safety Manuals and All Safety Regulations/Requirements
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Assume responsibility for the personal safety of oneself and others;
- b. Develop a personal attitude towards safety;
- c. Interpret safety manual directives;
- d. Identify and control common machine shop hazards; and,
- e. Comply with established company safety practices.

Module Outline:

- I. Assume Responsibility for the Personal Safety of Oneself and Others
  - A. Safety is a way of life not an option
  - B. Always operate with alertness and safety foremost in mind
- II. Develop a Personal Attitude Towards Safety
  - A. The key to safety is individual safety
  - B. Everyone must develop a safe attitude
  - C. Each step of the operation must be carefully planned
- III. Interpret Safety Manual Directives
  - A. Read and understand safety manual
  - B. Read machine operation instructions
- IV. Comply with Established Safety Practices
  - A. Personal safety
    - 1. Body: keep body out of line of tool edge
    - 2. Proper lifting technique
      - a. Personal lifting
        - 1) Lift with the legs, not the back
        - 2) Proper physical position while lifting
        - 3) Proper clearance for carrying
        - 4) "Buddy system" for heavy lifting
      - b. Equipment lifting
        - 1) Checking ratings for lifting devices
        - 2) Checking lifting points on lifted item
        - 3) Overhead clearance requirements
        - 4) Static lifting devices (slings, jack stands) should be used instead of moving lifting devices (jacks or forklifts) for actually holding heavy items up while working on them
  - B. Eyes: always wear safety glasses
  - C. Head: keep long hair up; wear hard hat whenever required

- D. Ears: wear protection to prevent damage from noise
- E. Jewelry: no rings, watches, bracelets, necklaces (they can get caught in machinery and they are conductors of electricity)
- F. Clothing: keep sleeves and pant legs rolled down; and ties, strings, and belts away from moving parts
- G. No horse-play
- H. Do not talk to someone while that person is operating a machine
- I. Do not talk to someone while you are operating a machine

V. Identify and Control Common Machine Shop Hazards
- A. Chip formation
- B. Moving machine parts
- C. Spills and other debris
- D. Electrical lines
- E. Hydraulic and pneumatic lines

VI. Cover specific safety policies of the company

MFG-A1-LE

Follow Safety Manuals and All Safety Regulations/Requirements

Attachment 2: MASTER Laboratory Exercise

The purpose of this exercise is to learn to recognize hazards in the workplace. Many of the hazards which you will find there are common practices by people who simply no longer see the danger.

The instructor will guide all students through part of the facility. Each student should write down, in the space provided below, as many safety hazards as are found.

Remember, anyone can cause a hazard merely by failing to see the mop bucket that sits in front of the fire exit every day. Such tunnel vision is the result of familiarity and demonstrates the importance of keeping a fresh perspective *everyday*.

Due to the nature of this laboratory exercise, no answer key is possible.

Safety Hazards

Type	Location	Description

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name________________________ Date______________

MFG-A1
Follow Safety Manuals and All Safety Regulations/Requirements
Self-Assessment

Circle the letter preceding the correct answer.

1. A positive attitude towards safety:
   - A. Is the responsibility of the individual.
   - B. Is the responsibility of management.
   - C. Can be developed by all workers, regardless of their work.
   - D. All of the above
   - E. None of the above answers is correct.

2. When is jewelry permitted to be worn?
   - A. On slow moving machinery
   - B. If all guards are in place
   - C. Never
   - D. If your supervisor knows
   - E. None of the above answers is correct.

3. Most accidents occur because:
   - A. Almost every tool is unsafe.
   - B. There is an unsafe condition and an unsafe action.
   - C. Workers lack motivation.
   - D. There is a practical joker in every plant.
   - E. None of the above answers is correct.

4. Who is responsible for safety on the job?
   - A. Management and employees
   - B. Employees
   - C. Union
   - D. Government
   - E. None of the above answers is correct.

5. Your most important motivation for working safely is to:
   - A. Get a raise.
   - B. Avoid being suspended.
   - C. Protect yourself.
   - D. Avoid working too hard.
   - E. None of the above answers is correct.

6. Your best protection against accidents is often:
   - A. Alertness.
   - B. Union policy.
   - C. Close supervision.
   - D. Buddy system.
   - E. None of the above answers is correct.

7. Which of the following three things is more important than natural skill in doing a job well and safely?
   - A. Training
   - B. Attitude
   - C. Alertness
   - D. All of the above
   - E. None of the above answers is correct.

8. When you spot something dangerous in your plant, the first thing you should do is:
   - A. Notify OSHA.
   - B. Report it to your supervisor.
   - C. Note it in the company safety log.
   - D. Walk off the job.
   - E. None of the above answers is correct.

9. OSHA regulations state that machines or equipment are safe after they are:
   - A. Locked or tagged out.
   - B. Turned off.
   - C. Assumed de-energized.
   - D. Written in the maintenance log.
   - E. None of the above answers is correct.

10. Before operating machines, the operators should:
    - A. Ask a co-worker.
    - B. Operate them until they learn how.
    - C. Read all the operating manuals.
    - D. Wear gloves.
    - E. None of the above answers is correct.

MFG-A1
Follow Safety Manuals and All Safety Regulations/Requirements
Self-Assessment Answer Key

1. D

2. C

3. B

4. A

5. C

6. A

7. D

8. B

9. A

10. C

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-A2

Subject: Manufacturing Technology **Time:** 2 Hrs.

Duty: Practice Safety
Task: Use Protective Equipment

Objective(s):

Upon completion of this unit the student will be able to:

a. Wear protective safety clothing as required;
b. Maintain and use protective guards and equipment on machinery;
c. Locate and properly use protective equipment; and,
d. Use lifting aids when necessary.

Instructional Materials:

MASTER Handout (MFG-A2-HO)
MASTER Laboratory Exercise (MFG-A2-LE)
MASTER Laboratory Aid (MFG-A2-LA)
MASTER Self-Assessment

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, Unit 1
OSHA General Industry Requirements, U. S. Government Printing Office, Latest Edition

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Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-A1 "Follow Safety Manuals and All Safety Regulations/Requirements"

Introduction:

Safety is taught by schools and industries but it is up to the individual worker to put it into practice. Read the rules and regulations to know what clothing is safe for the job you are doing. Other manuals tell you how to safely operate and service machinery and equipment. There are also safety tips on how to lift or use lifting aids when moving or lifting is done. Being safe never takes as long as getting well.

Presentation Outline:

- I. Wear Protective Safety Clothing as Required
  - A. Different types of safety clothing
    - 1. Protective from debris, cuts, and blows
      - a. Hard hat, safety glasses or goggles, work gloves when necessary
      - b. Sturdy footwear
      - c. Long sleeved shirt (sleeves rolled down and buttoned)
    - 2. Fire-retardant and fire-resistant clothing
      - a. Long sleeved, 100% cotton shirt
      - b. Long pants, 100% cotton
      - c. Leather chest protector, sleeves
    - 3. Optical filters to protect vision from intense light
      - a. Welding hood or goggles
      - b. Safety glasses or goggles for grinding
      - c. Tinted goggles for cutting torch work
    - 4. Breathing protection
      - a. Mask for dust, lint, smoke
  - B. Function and use of safety clothing
    - 1. Man made fiber clothing melts to worker's skin when ignited
    - 2. Prevents cuts and abrasions
    - 3. Keep shirt sleeves rolled down (hangs on equipment)
    - 4. Do not cuff pant legs (causes tripping)
    - 5. Do not wear jewelry
      - a. Catches in moving parts
      - b. Conducts electricity
    - 6. Do not wear neckties around moving parts of machinery
    - 7. Keep belts and apron strings tied and away from moving equipment
- II. Maintain and Use Protective Guards and Equipment on Machinery
  - A. Purposes of various guards
    - 1. Do not operate a machine until guards are in place
    - 2. Stop the machine to make adjustments or repairs
    - 3. Disconnect power before removing guards or panels
  - B. Evaluation and maintenance of protective equipment
    - 1. Use only those electrical devices which have been approved by UL (Underwriters' Laboratories)
    - 2. Do not use defective equipment
    - 3. Report defective or unsafe equipment immediately
    - 4. Make sure equipment is properly grounded
- III. Locate and Properly Use Protective Equipment
  - A. Install safety barriers

B. Use caution signs
C. Install lock and tag devices
D. Know where fire extinguishers are and how to use them

IV. Use Lifting Aids When Necessary
  A. Discuss recommended limits on single-person lifting
  B. Discuss proper lifting methods (use of the legs)
    1. Use your legs (bend your knees)
    2. Keep the load close to your body
    3. Don't twist your body while lifting
    4. Make sure you can see where you are going
    5. Wear support belts
  C. Discuss team-lifting
    1. Keep load the same height while lifting
    2. Move and lift on command
    3. Use dolly, wheelbarrow, or forklift
  D. Determine lifting ratings of lifting equipment
    1. Know how your forklift operates
    2. Understand load characteristics (weight, size, shape)
  E. Determine holding ratings of static lifting devices
  F. Evaluate positions on the workpiece for placement of lifting and holding devices

Practical Application:

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-A3) dealing with the safe operating procedures for hand and machine tools.

MFG-A2-HO
Use Protective Equipment
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Wear protective safety clothing as required;
- b. Maintain and use protective guards and equipment on machinery;
- c. Locate and properly use protective equipment; and,
- d. Use lifting aids when necessary.

Module Outline:

- I. Wear Protective Safety Clothing as Required
  - A. Different types of safety clothing
    - 1. Protective from debris, cuts, and blows
      - a. Hard hat, safety glasses or goggles, work gloves when necessary
      - b. Sturdy footwear
      - c. Long sleeved shirt (sleeves rolled down and buttoned)
    - 2. Fire-retardant and fire-resistant clothing
      - a. Long sleeved, 100% cotton shirt
      - b. Long pants, 100% cotton
      - c. Leather chest protector, sleeves
    - 3. Optical filters to protect vision from intense light
      - a. Welding hood or goggles
      - b. Safety glasses or goggles for grinding
      - c. Tinted goggles for cutting torch work
    - 4. Breathing protection
      - a. Mask for dust, lint, smoke
  - B. Function and use of safety clothing
    - 1. Man made fiber clothing melts to worker's skin when ignited
    - 2. Prevents cuts and abrasions
    - 3. Keep shirt sleeves rolled down (hangs on equipment)
    - 4. Do not cuff pant legs (causes tripping)
    - 5. Do not wear jewelry
      - a. Catches in moving parts
      - b. Conducts electricity
    - 6. Do not wear neckties around moving parts of machinery
    - 7. Keep belts and apron strings tied and away from moving equipment
- II. Maintain and Use Protective Guards and Equipment on Machinery
  - A. Purposes of various guards

    - 1. Do not operate a machine until guards are in place
    - 2. Stop the machine to make adjustments or repairs
    - 3. Disconnect power before removing guards or panels
  - B. Evaluation and maintenance of protective equipment
    - 1. Use only those electrical devices which have been approved by UL (Underwriters' Laboratories)
    - 2. Do not use defective equipment
    - 3. Report defective or unsafe equipment immediately
    - 4. Make sure equipment is properly grounded
- III. Locate and Properly Use Protective Equipment
  - A. Install safety barriers
  - B. Use caution signs
  - C. Install lock and tag devices
  - D. Know where fire extinguishers are and how to use them
- IV. Use Lifting Aids When Necessary
  - A. Discuss recommended limits on single-person lifting
  - B. Discuss proper lifting methods (use of the legs)
    - 1. Use your legs (bend your knees)
    - 2. Keep the load close to your body
    - 3. Don't twist your body while lifting
    - 4. Make sure you can see where you are going
    - 5. Wear support belts
  - C. Discuss team-lifting
    - 1. Keep load the same height while lifting
    - 2. Move and lift on command
    - 3. Use dolly, wheelbarrow, or forklift
  - D. Determine lifting ratings of lifting equipment
    - 1. Know how your forklift operates
    - 2. Understand load characteristics (weight, size, shape)
  - E. Determine holding ratings of static lifting devices
  - F. Evaluate positions on the workpiece for placement of lifting and holding devices

MFG-A2-LE
Use Protective Equipment
Attachment 2: MASTER Laboratory Exercise

The instructor will display as much protective equipment, such as welding masks, breathers, and hard hats as is practical and desirable. The instructor should demonstrate the proper use of this equipment.

Due to the nature of this exercise, no answer key is possible.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name__________________________ Date_______________

MFG-A2
Use Protective Equipment
Self-Assessment

Circle the letter preceding the correct answer.

1. Back injuries, often from poor ________ are the most common type of serious occupational injury.
   - A. Lifting techniques
   - B. Muscle structure
   - C. Attitude adjustment
   - D. Warm-up

2. If a load is too heavy, get help or use a special:
   - A. Lifting techniques.
   - B. Mechanical device.
   - C. Platforms.
   - D. Friends.

3. When lifting or lowering from high places, stand on a:
   - A. Ladder.
   - B. Chair.
   - C. Platform.
   - D. Box.

4. Energy can be mechanical, _____________, hydraulic, or pneumatic.
   - A. Powerful
   - B. Electrical
   - C. Inactive
   - D. All of the above

5. One step in the lockout procedure is to ___________ to make sure the power is off.
   - A. Test the operating controls
   - B. Ask your supervisor
   - C. Check with co-workers
   - D. Turn switch off

6. Remember, ___________ alone don't prevent equipment from starting up.
   - A. Locks
   - B. Verbal instructions
   - C. Tags
   - D. All of the above

7. Which of the following are unsafe in the industrial workplace?
   A. Jewelry
   B. Man-made fiber clothing
   C. Open-toe shoes
   D. All of the above

8. Proper protection equipment for a welder always includes all of the following except:
   A. Eye protection.
   B. Ear protection.
   C. Flame-resistant gloves.
   D. Gas mask.

9. Ultraviolet rays are harmful when welding because they produce:
   A. Intense heat.
   B. Skin cancer.
   C. Eye damage.
   D. Metal fatigue.

10. In double insulated tools, protection against electric shock is provided by the:
   A. Insulated case or liner.
   B. Two-wire supply cord.
   C. Three-wire supply cord.
   D. Lug.

11. It is good practice to connect the neutral conductor and the metallic conduit of an electrical circuit to a common ground, because doing so:
   A. Eliminates ground faults.
   B. Provides more protection against shock.
   C. Reduces fault current.
   D. Improves the voltage in the circuit.

12. Damaged or deteriorated conductors on machinery or equipment should be:
   A. Separated.
   B. Replaced.
   C. Taped.
   D. Reported.

13. All equipment should be inspected before use.
   A. True
   B. False

14. Guards may be left off equipment for frequent servicing while the equipment is running.
    A. True
    B. False

15. It is permissible to loan your lock out key to co-workers.
    A. True
    B. False

MFG-A2
Use Protective Equipment
Self-Assessment Answer Key

1. A
2. B
3. C
4. B
5. A
6. C
7. D
8. D
9. C
10. A
11. B
12. B
13. A
14. B
15. B

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-A3

Subject: **Manufacturing Technology** **Time: 2 Hrs.**

Duty: **Practice Safety**
Task: Follow Safe Operating Procedures for Hand and Machine Tools

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Objective(s):

Upon completion of this unit the student will be able to:
a. Identify and understand safe machine operating procedures; and,
b. Demonstrate safe machine operation.

Instructional Materials:

MASTER Handout (MFG-A3-HO)
MASTER Laboratory Exercise (MFG-A3-LE)
MASTER Laboratory Aid (MFG-A3-LA)
MASTER Self-Assessment
Operation manuals for all covered machines

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, Unit 1
OSHA General Industry Requirements, U. S. Government Printing Office, Latest Edition

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Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-A1 "Follow Safety Manuals and All Safety Regulations/Requirements"
MFG-A2 "Use Protective Equipment"

Introduction:

The reason that there are safety guards on machines is to prevent accidents. Read the operating manuals and train for the operation of the machine before attempting to use it. You cannot always tell whether a part is moving or energized by just looking at it. Before working on the machine, always bring the machine to a zero energy state. The more you learn about the machine, the safer and easier your work will be.

Presentation Outline:

- I. Identify and Understand Safe Machine Operating Procedures
  - A. Never make adjustments on a machine while it is running
    - 1. Keep guards in place at all times
    - 2. Discontinue power before servicing
    - 3. Keep body parts clear of moving machinery
    - 4. Beware of sharp edges and flying debris
    - 5. Secure work pieces to prevent slipping
    - 6. Never stand directly in line with blades or knives
    - 7. Avoid kickback
    - 8. Feed stack into machine correctly
  - B. Electrical safety
    - 1. Use only those electrical devices which have been approved by UL (Underwriters' Laboratories)
    - 2. Stand on dry surface when working on electrical equipment
    - 3. Replace defective cords or plugs on equipment
    - 4. Use only those tools that are in good condition
    - 5. Use only carbon dioxide or dry chemical fire extinguishers for control of electrical fires
    - 6. Obtain help when working on equipment that may become energized
  - C. Avoid horseplay and practical jokes
  - D. Keep work area clean.
- II. Demonstrate Safe Machine Operation
  - A. Good housekeeping
    - 1. Materials and equipment should be stacked straight and neat
    - 2. Keep aisles and walkways clear of tools, materials, and debris
    - 3. Dispose of scraps and rubbish daily
    - 4. Clean up spills
    - 5. Clean and store hand tools
  - B. Good techniques
    - 1. Always walk - do not run
    - 2. Never talk to or interrupt anyone who is operating a machine
    - 3. Never leave tools or pieces of stock lying on table surface of a machine being used
    - 4. When finished with a machine, turn power OFF and wait until blades or cutters have come to a complete stop before leaving
    - 5. Check stock for defects before machining
      - a. Do not use a machine until you understand it thoroughly
      - b. Do not jam or rush stock into machinery
      - c. Keep guards in place
      - d. Make sure power is OFF before working on or servicing

    6. Keep hands and fingers away from moving parts
    7. Don't try to run too small a piece through the machine
    8. Use a brush to clean the surface table
    9. Keep your eyes focused on what you are working on
    10. Never use an air hose to blow debris off yourself or other workers
    11. Report faulty machinery to your supervisor
    12. Make sure machinery is properly grounded
    13. Never leave a piece of machinery that is running unattended
    14. Make sure stack is solidly supported

C. Miscellaneous materials
    1. Molten metal - can splash and cause serious burns
    2. Chemicals - burn or irritate the skin or cause eye damage
    3. Broken glass - causes cuts, can get in the eyes
    4. Pointed objects - knives, screwdrivers, punches, staples can puncture the skin
    5. Rough material - can scrape your skin and cause infections

D. Machinery
    1. Understand the safety regulations that involve the guarding of moving parts
    2. Know what parts of the equipment are energized
    3. Use all safeguards that have been provided to protect people from machinery
    4. See that all guards and protectors are in place before you start to work
    5. If you must work nearer, turn the machine off and lock out the power
    6. Never work in, around, or near dangerous, unguarded openings without wearing a safety belt and a lifeline that is properly seamed

E. One-fifth of all injuries on the job involve moving parts, machinery, or tools

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Practical Application:

The students shall identify all major safeguards and protective devices on all covered machinery.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-A4) dealing with maintaining a clean and safe work environment

MFG-A3-HO
Follow Safe Operating Procedures for Hand and Machine Tools
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify and understand safe machine operating procedures; and,

b. Demonstrate safe machine operation.

Module Outline:

I. Identify and Understand Safe Machine Operating Procedures
  A. Never make adjustments on a machine while it is running
    1. Keep guards in place at all times
    2. Discontinue power before servicing
    3. Keep body parts clear of moving machinery
    4. Beware of sharp edges and flying debris
    5. Secure work pieces to prevent slipping
    6. Never stand directly in line with blades or knives
    7. Avoid kickback
    8. Feed stack into machine correctly
  B. Electrical safety
    1. Use only those electrical devices which have been approved by UL (Underwriters' Laboratories)
    2. Stand on dry surface when working on electrical equipment
    3. Replace defective cords or plugs on equipment
    4. Use only those tools that are in good condition
    5. Use only carbon dioxide or dry chemical fire extinguishers for control of electrical fires
    6. Obtain help when working on equipment that may become energized
  C. Avoid horseplay and practical jokes
  D. Keep work area clean.

II. Demonstrate Safe Machine Operation
  A. Good housekeeping
    1. Materials and equipment should be stacked straight and neat
    2. Keep aisles and walkways clear of tools, materials, and debris
    3. Dispose of scraps and rubbish daily
    4. Clean up spills
    5. Clean and store hand tools
  B. Good techniques
    1. Always walk - do not run
    2. Never talk to or interrupt anyone who is operating a machine

3. Never leave tools or pieces of stock lying on table surface of a machine being used
4. When finished with a machine, turn power OFF and wait until blades or cutters have come to a complete stop before leaving
5. Check stock for defects before machining
    a. Do not use a machine until you understand it thoroughly
    b. Do not jam or rush stock into machinery
    c. Keep guards in place
    d. Make sure power is OFF before working on or servicing
6. Keep hands and fingers away from moving parts
7. Don't try to run too small a piece through the machine
8. Use a brush to clean the surface table
9. Keep your eyes focused on what you are working on
10. Never use an air hose to blow debris off yourself or other workers
11. Report faulty machinery to your supervisor
12. Make sure machinery is properly grounded
13. Never leave a piece of machinery that is running unattended
14. Make sure stack is solidly supported

C. Miscellaneous materials
1. Molten metal - can splash and cause serious burns
2. Chemicals - burn or irritate the skin or cause eye damage
3. Broken glass - causes cuts, can get in the eyes
4. Pointed objects - knives, screwdrivers, punches, staples can puncture the skin
5. Rough material - can scrape your skin and cause infections

D. Machinery
1. Understand the safety regulations that involve the guarding of moving parts
2. Know what parts of the equipment are energized
3. Use all safeguards that have been provided to protect people from machinery
4. See that all guards and protectors are in place before you start to work
5. If you must work nearer, turn the machine off and lock out the power
6. Never work in, around, or near dangerous, unguarded openings without wearing a safety belt and a lifeline that is properly seamed

E. One-fifth of all injuries on the job involve moving parts, machinery, or tools

MFG-A3-LE
Follow Safe Operating Procedures for Hand and Machine Tools
Attachment 2: MASTER Laboratory Exercise

For this exercise, the instructor should allow the students to observe other workers at their stations. The students should look for only practices related to safety. Upon returning to class, the students and instructor should discuss what they saw.

NOTE TO ALL STUDENTS: Unless your instructor tells you otherwise, all questions are to be directed to the instructor only. Do **not** disturb you fellow workers at their stations. Such distractions, in and of themselves, pose risks!

Due to the nature of this exercise, no answer key is possible.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name____________________________ Date________________

MFG-A3

Follow Safe Operating Procedures for Hand and Machine Tools

Self-Assessment

Circle the letter preceding the correct answer.

1. Barrier guards ____________ the operator's access to the danger zone.
    A. Limit
    B. Prevent
    C. Stop the operator from entering maintenance area
    D. All of the above

2. Equipment grounding is accomplished by a separate wire which is colored:
    A. White.
    B. Black.
    C. Green.
    D. Red.

3. "Intrinsically safe" equipment is designed so that it cannot:
    A. Become damaged if dropped.
    B. Ignite materials nearby.
    C. Start its built-in alarm.
    D. Eliminate ground faults.

4. When making repairs on machinery the most important rule is to:
    A. Lock-out and tag-out.
    B. Report and document.
    C. Install barricades.
    D. Notify co-workers.

5. Safety guards would not be needed on machines if:
    A. Workers would be more careful.
    B. Machines had no moving parts.
    C. Safety rules were strictly enforced.
    D. Machines were better designed.

6. When you do maintenance work you are safer if you wear:
   A. A good-luck charm bracelet.
   B. Loose, comfortable clothing.
   C. Tight-fitting clothing.
   D. A narrow necktie.

7. Which of the following is not a pinch point?
   A. Where a belt meets a pulley
   B. Where a chain meets a sprocket
   C. Where a belt passes close to a fixed object
   D. Where a drill bit meets a work piece

8. After you have locked out the power to a machine, you should:
   A. Make sure all moving parts have stopped.
   B. Drain the hydraulic and pneumatic lines.
   C. Block any parts that might move.
   D. Do all of the above.

9. Debris should be cleared from machines using your:
   A. Bare hands.
   B. High pressure air hose.
   C. Brush.
   D. Neither, leave it for the next shift.

10. Which of the following statements is correct?
   A. Understand the safety regulations that involve the guarding of moving parts.
   B. Knowing what parts of the equipment are energized.
   C. Use all safeguards to protect people.
   D. All of the above.

11. You should begin work on a machine only after:
   A. The supervisor tells you to.
   B. You have read operating instructions and have been properly trained.
   C. Warned other people.
   D. All of the above.

12. Only authorized employees are permitted to install or remove locks or tags.
   A. True
   B. False

13. If a machine can't be locked or tagged a guard should be stationed at the controls.
A. True
B. False

14. It is permissible to talk to persons operating a piece of machinery.
A. True
B. False

15. Feed and extracting tools make it unnecessary for the operator to reach into the danger zone.
A. True
B. False

MFG-A3
Follow Safe Operating Procedures for Hand and Machine Tools
Self-Assessment Answer Key

1. A
2. C
3. B
4. A
5. B
6. C
7. D
8. D
9. C
10. D
11. B
12. A
13. A
14. B
15. A

MFG-A4

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-A4

Subject: **Manufacturing Technology** **Time: 4 Hrs.**

Duty: **Practice Safety**
Task: Maintain a Clean and Safe Work Environment

Objective(s):

Upon completion of this unit the student will be able to:

a. Keep work areas clean;
b. Clean machine/hand tools when work is completed;
c. Put tools away when work is finished;
d. Keep isles clear of equipment and materials;
e. Perform preventive maintenance as required; and,
f. Understand chemical hazards and the use of Material Safety Data Sheets (MSDS).

Instructional Materials:

MASTER Handout (MFG-A4-HO)
MASTER Laboratory Exercise (MFG-A4-LE)
MASTER Laboratory Aid (MFG-A4-LA)
MASTER Self-Assessment

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, Unit 1
OSHA General Industry Requirements, U. S. Government Printing Office, Latest Edition
Materials Safety Data Sheets

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1 "Follow Safety Manuals and All Safety Regulations/Requirements"
MFG-A2 "Use Protective Equipment"
MFG-A3 "Follow Safe Operating Procedures for Hand and Machine Tools"

Introduction:

Cleanliness is the first rule of safety. A clean neat work area helps prevent accidents. A cluttered area invites slips, trips, or falls. Clean up around your machine or equipment. If you are unable to do so, ask your supervisor for a helper to clean or stack material. Clean and store tools when you are finished and keep cords and hoses rolled up. Most accidents are caused by workers who do unsafe things. Learn to do your part by helping to create a safe work environment.

Presentation Outline:

- I. Keep Work Areas Clean
  - A. Discuss the associated dangers of the most common hazards of the work place
    - 1. Tripping/falling hazards caused by spills, loose objects, etc.
      - a. Wipe up spills immediately
      - b. Dispose of scrap material
      - c. Do not wear loose clothing
      - d. Never roll sleeves or pants
      - e. keep shoe strings tied
      - f. Position electrical cords and air hoses in safe areas
    - 2. Chemical hazards
      - a. Inhalants
      - b. Chemical burns
      - c. Flammable liquids
      - d. Explosives and explosive combinations
      - e. Toxins
    - 3. Electrical hazards
    - 4. High-pressure hazards
  - B. Discuss methods of avoiding and correcting common hazards
- II. Clean Machine/Hand Tools When Work Is Completed
- III. Put Tools Away When Work Is Finished
- IV. Keep Isles Clear of Equipment and Materials
- V. Perform Preventive Maintenance as Required
  - A. Discuss that certain machines require extra precautions
  - B. Discuss how general maintenance enhances general safety
- VI. Understand the Use of Material Safety Data Sheets (MSDS)
  - A. What chemicals have MSDS?
  - B. Where are the MSDS kept?
  - C. What information is on the MSDS?
    - 1. Product identification
      - a. Specific product name and common name
      - b. Precautionary labeling
      - c. Safety equipment

    d. Precautionary label statements
    e. Storage color code
2. Hazardous components
3. Physical data
    a. Boiling point
    b. Vapor pressure
    c. Melting point
    d. Vapor density
    e. Specific gravity
    f. Evaporation rate
    g. Solubility in water
    h. Percentage of volatile components by volume
    I. Appearance & odor
4. Fire and explosion hazard data
    a. Flash point
    b. NFPA 704M rating
    c. Flammable limits (upper and lower)
    d. Fire extinguishing media
    e. Special fire-fighting procedures
    f. Toxic gases produced
5. Health hazard data
    a. Threshold limit value
    b. Permissible exposure limit
    c. Toxicity
    d. Carcinogenicity
    e. Effects of over-exposure
    f. Target organs (those most affected by exposure)
    g. Medical conditions aggravated by exposure
    h. Routes of entry
    I. Emergency and first-aid procedures
6. Reactivity data
    a. Stability
    b. Hazardous polymerization
    c. Conditions to avoid
    d. Incompatible materials
    e. Decomposition products
7. Spill and disposal procedures
    a. Procedures: spill or discharge
    b. Procedures: disposal
    c. EPA hazardous waste number
8. Protective equipment
    a. Ventilation
    b. Respiratory protection
    c. Eye/skin protection
9. Storage and handling precautions

    a. Storage color code
    b. Special precautions

10. Transportation data and additional information
    a. Domestic transport
        1) DOT shipping name
        2) Hazard class
        3) UN/NA
        4) Labels
        5) Reportable quantity
    b. International
        1) IMO shipping name
        2) Hazard class
        3) UN/NA
        4) Labels

Practical Application:

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-A5) dealing with lifting safely.

MFG-A4-HO
Maintain a Clean and Safe Work Environment
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Keep work areas clean;
- b. Clean machine/hand tools when work is completed;
- c. Put tools away when work is finished;
- d. Keep isles clear of equipment and materials;
- e. Perform preventive maintenance as required; and,
- f. Understand chemical hazards and the use of Material Safety Data Sheets (MSDS).

Module Outline:

- I. Keep Work Areas Clean
  - A. Discuss the associated dangers of the most common hazards of the work place
    - 1. Tripping/falling hazards caused by spills, loose objects, etc.
      - a. Wipe up spills immediately
      - b. Dispose of scrap material
      - c. Do not wear loose clothing
      - d. Never roll sleeves or pants
      - e. keep shoe strings tied
      - f. Position electrical cords and air hoses in safe areas
    - 2. Chemical hazards
      - a. Inhalants
      - b. Chemical burns
      - c. Flammable liquids
      - d. Explosives and explosive combinations
      - e. Toxins
    - 3. Electrical hazards
    - 4. High-pressure hazards
  - B. Discuss methods of avoiding and correcting common hazards
- II. Clean Machine/Hand Tools When Work Is Completed
- III. Put Tools Away When Work Is Finished
- IV. Keep Isles Clear of Equipment and Materials
- V. Perform Preventive Maintenance as Required
  - A. Discuss that certain machines require extra precautions
  - B. Discuss how general maintenance enhances general safety
- VI. Understand the Use of Material Safety Data Sheets (MSDS)
  - A. What chemicals have MSDS?

B. Where are the MSDS kept?
C. What information is on the MSDS?
  1. Product identification
    a. Specific product name and common name
    b. Precautionary labeling
    c. Safety equipment
    d. Precautionary label statements
    e. Storage color code
  2. Hazardous components
  3. Physical data
    a. Boiling point
    b. Vapor pressure
    c. Melting point
    d. Vapor density
    e. Specific gravity
    f. Evaporation rate
    g. Solubility in water
    h. Percentage of volatile components by volume
    I. Appearance & odor
  4. Fire and explosion hazard data
    a. Flash point
    b. NFPA 704M rating
    c. Flammable limits (upper and lower)
    d. Fire extinguishing media
    e. Special fire-fighting procedures
    f. Toxic gases produced
  5. Health hazard data
    a. Threshold limit value
    b. Permissible exposure limit
    c. Toxicity
    d. Carcinogenicity
    e. Effects of over-exposure
    f. Target organs (those most affected by exposure)
    g. Medical conditions aggravated by exposure
    h. Routes of entry
    I. Emergency and first-aid procedures
  6. Reactivity data
    a. Stability
    b. Hazardous polymerization
    c. Conditions to avoid
    d. Incompatible materials
    e. Decomposition products
  7. Spill and disposal procedures
    a. Procedures: spill or discharge
    b. Procedures: disposal

    - c. EPA hazardous waste number
8. Protective equipment
    - a. Ventilation
    - b. Respiratory protection
    - c. Eye/skin protection
9. Storage and handling precautions
    - a. Storage color code
    - b. Special precautions
10. Transportation data and additional information
    - a. Domestic transport
        - 1) DOT shipping name
        - 2) Hazard class
        - 3) UN/NA
        - 4) Labels
        - 5) Reportable quantity
    - b. International
        - 1) IMO shipping name
        - 2) Hazard class
        - 3) UN/NA
        - 4) Labels

MFG-A4-LE
Maintain a Clean and Safe Work Environment
Attachment 2: MASTER Laboratory Exercise

The instructor will guide all students through part of the facility. Each student should write down as many safety hazards as are found. While this may appear to be an exact duplicate of MFG-A1, the purpose of this exercise is to determine how much more aware of safety and hazards the students have become.

Upon returning to class, the students and the instructor should discuss what the students observed on this tour. Each student should compare his answers to those from MFG-A1, noting any differences and the reasons for those differences.

Due to the nature of this laboratory exercise, no answer key is possible.

Safety Hazards

Type	Location	Description	Recommendations

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name________________________ Date_______________

MFG-A4
Maintain a Clean and Safe Work Environment
Self-Assessment:

Circle the letter preceding the correct answer.

1. A chemical label tells:
    - A. The carrier where to send the container
    - B. Only what the manufacture wants you to know
    - C. Only the maximum hazard
    - D. What a chemical's identity is

2. Labels are an important part of:
    - A. Your company's Hazard Communication Program
    - B. Right to know
    - C. Both a and b
    - D. Neither a nor b

3. On some labels, ___ represent the kind of hazards and ___ represent the degree of hazard.
    - A. Colors . . . numbers
    - B. Caution . . . danger
    - C. OSHA . . . MDS
    - D. All of the above

4. Before you start any jobs with chemicals, check the detailed hazard and safety information on the:
    - A. Supervisor's desk
    - B. Material Safety Data Sheet
    - C. Dock
    - D. Poison control center

5. Chemicals can enter the body by:
    - A. Swallowing
    - B. Inhaling
    - C. Skin contact
    - D. All of the above

6. The Control Measures Section of the MSDS covers the:
    - A. Protective equipment you might need
    - B. Exposure limits
    - C. Temperature limits
    - D. Spill and leak

7. Which of the following is *not* a good housekeeping rule?
   - A. Always put tools in their proper place
   - B. Dispose of waste material properly
   - C. Sweep debris from machine with hands
   - D. Wipe up spills immediately

8. Which of the following is a fire risk?
   - A. Disposing of oily rags in tightly covered containers
   - B. Storing flammables in electrical closets
   - C. Keeping motors and machines free of dust and grease
   - D. Keeping passages and fire exits clear

9. Before performing maintenance on a machine you should:
   - A. Shut off power
   - B. Warn other people
   - C. Bring the machine to a zero energy state
   - D. Lock-out power and the valves

10. If you have to work on a suspended load you should:
    - A. Make sure you have clearance
    - B. Place barricades around the hoist
    - C. Watch out for pedestrians
    - D. Set the load down first

11. Flammable liquids should be stored in:
    - A. Open metal containers
    - B. Sealed metal containers
    - C. Open glass containers
    - D. Sealed glass containers

12. During maintenance, the controls of a power-driven conveyor should be locked in the OFF position to prevent:
    - A. Start-up
    - B. Theft
    - C. Damage
    - D. Fire

13. When working aloft, you need:
    - A. Guard rail clamps
    - B. Safety toed shoes
    - C. A safety harness
    - D. A helper posted below

14. Scrap material should be:
   - A. Stacked around the machine
   - B. Cleared from the area
   - C. Swept out in aisles
   - D. All of the above

15. Danger that is part of the job is a:
   - A. Built-in hazard
   - B. Walk-on hazard
   - C. Accident chain
   - D. Hazardous duty
   - E. Problem for the insurance company, not me

MFG-A4

Maintain a Clean and Safe Work Environment

Self-Assessment Answer Key

1. D
2. C
3. A
4. B
5. D
6. A
7. C
8. B
9. C
10. D
11. B
12. A
13. C
14. B
15. A

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-A5

Subject:	**Manufacturing Technology**	**Time: 3 Hrs.**
Duty:	**Practice Safety**	
Task:	Lift Safely	

Objective(s):

Upon completion of this module the student will be able to:

a. Identify the consequences of improper lifting techniques;
b. Recognize when it is unsafe to lift an object alone;
c. Demonstrate proper lifting techniques; and,
d. Identify safety concerns to be addressed when lifting rough, sharp or fragile items.

Instructional Materials:

1. Large Empty Cardboard Box
2. Pencil
3. Paper
4. Gloves
5. Safety Glasses
6. Hand Truck
7. Conveyor
8. Chains
9. Sling
10. Face Shield
11. Side Shield
12. **MASTER** Handout (MFG-A5-HO)
13. **MASTER** Laboratory Exercise (MFG-A5-LE)
14. **MASTER** Laboratory Aid (MFG-A5-LA)
15. Copy of 29 CFR 1910 Regulations

References:

First Aid Textbook, American National Red Cross, 17th and D Sts. NW., Washington DC 20006, Latest Edition

Approval Guide; Handbook of Property Conservation; and *Loss Prevention Data,* Factory Mutual Engineering Corporation of the Factory

Mutual System, 1151 Boston -Providence Turnpike, Norwood, MA 02062, Latest Editions

Guide to Occupational Safety and Health Management, Firenze, Robert J., Dubuque, IA, Kendall/Hunt Publishing Co., Latest Edition

Supervisor's Guide to Human Relations, Hannaford, Earle S., Chicago, IL, National Safety Council, Latest Edition

IES Lighting Handbook (The Standard Lighting Guide); and *Practice for Industrial Lighting (ANSI A11.1-1965),* Laminating Engineering Society, 345 East 47th St., New York, NY 10017, Latest Editions

Encyclopedia of Occupational Health and Safety; and *Loss Control,* International Labor Organization, 666 11th St. NW., Washington, DC, 20001, Latest Edition

A Safety Guidebook for Trades and Services, Van Nostrand Reinhold Co., New York, NY, Latest Edition

Fire Prevention Handbook; Fire Protection Guide on Hazardous Materials; Inspection Manual; National Electrical Code, Std. No. 70 (ANSI CI-1971); National Fire Codes (10 Volumes); and *Standards and Recommended Practices,* National Fire Protection Association, 470 Atlantic Ave., Boston, MA 02210, Latest Editions

Maintaining a Healthy Back, - 15m - Video Tape - Ergodyne Corp., Latest Edition

Lifting, Eye Protection and Hand Tool Safety, - 20m - Video Tape - BBP, Latest Edition

Rigging, - Video Tape - ITS - Video Tape, Latest Edition

Basic Injury Prevention, - C.L.M. - Video Tape, Latest Edition

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Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1	"Follow Safety Manuals and All Safety Regulations/Requirements"
MFG-A2	"Use Protective Equipment"
MFG-A3	"Follow Safe Operating Procedures for Hand and Machine Tools"
MFG-A4	"Maintain a Clean and Safe Work Environment"

Introduction:

Injuries resulting from improper lifting probably are the number one cause of employee injury. A strong physically fit body is not enough to ensure you won't have back problems. Following time proven lifting methods and getting help when you need it is your best assurance. Remember you are responsible for your own safety.

Presentation Outline:

I. Discuss the Importance of Lifting Safely
    A. Give each student a copy of the following attachments:
        1. Laboratory aid
        2. Objectives, reading assignments, and module outline
        3. Laboratory worksheet
II. Identify the Steps to Manually Lift Safely
    A. Estimate the load to be lifted. If it is heavier than one person should attempt, get help.
    B. Place feet properly. Spread your feet slightly (comfortably), with one foot slightly ahead of the other and alongside the object.
    C. Bend knees, kneel, or squat. Get close enough to the load to reach under it without bending the back.
    D. Use blocking under objects to get a handhold and to prevent crushed fingers.
    E. Get a good grip. Be sure you can maintain your grip on the object. Use gloves when handling sharp or rough objects.
    F. Let the legs do the lifting. To rise, straighten your legs, letting the powerful leg, arm, and shoulder muscles do the lifting.
    G. Do not turn the body at the waist while carrying a load.
    H. Lower the load to the floor from the carrying position by bending the knees while keeping the back straight. This keeps the load on the leg and arm muscles. Keep fingers and toes clear as the load is set.
III. Discuss Handling Specific Shapes
    A. Locate center of gravity and use this area to lift
    B. Place as much weight as possible as close to lifting mechanism
    C. Place flat weight on button
IV. Discuss Equipment for Material Handling
    A. Hand Trucks
    B. Powered Trucks
    C. Conveyers
V. Discuss and Demonstrate Safe Use of Hand Trucks
    A. Place most of the weight on bed of hand truck
    B. May require two people if one object is difficult to lift on side
    C. Hold object tightly as handle is pulled back
    D. Adjust handle position so more weight is on hand end

   - E. After movement, hold object tightly as handle is moved upward
   - F. Lift object on one side so bed of truck can be moved away from object

- VI. Discuss and Demonstrate Use of Powered Hand Trucks
   - A. Watch out for people
   - B. Drive unit slowly
   - C. Use manual lifting rules
- VII. Discuss and Demonstrate Safe Use of Conveyers
   - A. Watch for pinch points
   - B. Exercise caution when loading and unloading objects
   - C. Do not overload conveyers. Rollers may not move freely
- VIII. Discuss and Demonstrate Safe Use of Chains and Slings
   - A. Storage area should be clean and dry
   - B. Watch for pinch points
   - C. Inspect for defects before using:
      - 1. Chains
         - a. Wear
         - b. Stretch
         - c. Distortion
         - d. Nicks
         - e. Cracks
         - f. Gauges
      - 2. Slings
         - a. Wear
         - b. Stretch
         - c. Distortion
         - d. Flat, Sling Spots
   - D. Types
      - 1. Slings
         - a. Choker
         - b. Double Choker
         - c. Bridle
         - d. Basket
         - e. Double Basket
- IX. Discuss and Demonstrate Safe Use of Chains and Slings

Practical Application:

Students will practice correct lifting techniques. Each student will then complete the Laboratory exercise where he will be graded on demonstrating proper lifting techniques.

Evaluation and Verification:

Successful completion of this Technical Module will be based on the student's successful completion of the practical evaluation.

Summary:

Review the main lesson points using the Handout (MFG-A5-HO) as a guide for discussion and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-A6) dealing with MSDS and control of chemical hazards.

MFG-A5-HO
Lift Safely
Attachment 1: **MASTER** Handout

Standards of Performance:

Student shall demonstrate safety work habits in the work shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

Objective(s):

Upon completion of this module the student will be able to:

a. Identify the consequences of improper lifting techniques;
b. Recognize when it is unsafe to lift an object alone;
c. Demonstrate proper lifting techniques; and,
d. Identify safety concerns to be addressed when lifting rough, sharp or fragile items.

Module Outline:

I. Discuss the Importance of Lifting Safely
  A. Give each student a copy of the following attachments:
    1. Laboratory aid
    2. Objectives, reading assignments, and module outline
    3. Laboratory worksheet
II. Identify the Steps to Manually Lift Safely
  A. Estimate the load to be lifted. If it is heavier than one person should attempt, get help.
  B. Place feet properly. Spread your feet slightly (comfortably), with one foot slightly ahead of the other and alongside the object.
  C. Bend knees, kneel, or squat. Get close enough to the load to reach under it without bending the back.
  D. Use blocking under objects to get a handhold and to prevent crushed fingers.
  E. Get a good grip. Be sure you can maintain your grip on the object. Use gloves when handling sharp or rough objects.

F. Let the legs do the lifting. To rise, straighten your legs, letting the powerful leg, arm, and shoulder muscles do the lifting.
G. Do not turn the body at the waist while carrying a load.
H. Lower the load to the floor from the carrying position by bending the knees while keeping the back straight. This keeps the load on the leg and arm muscles. Keep fingers and toes clear as the load is set.

III. Discuss Handling Specific Shapes
A. Locate center of gravity and use this area to lift
B. Place as much weight as possible as close to lifting mechanism
C. Place flat weight on button

IV. Discuss Equipment for Material Handling
A. Hand Trucks
B. Powered Trucks
C. Conveyers

V. Discuss and Demonstrate Safe Use of Hand Trucks
A. Place most of the weight on bed of hand truck
B. May require two people if one object is difficult to lift on side
C. Hold object tightly as handle is pulled back
D. Adjust handle position so more weight is on hand end
E. After movement, hold object tightly as handle is moved upward
F. Lift object on one side so bed of truck can be moved away from object

VI. Discuss and Demonstrate Use of Powered Hand Trucks
A. Watch out for people
B. Drive unit slowly
C. Use manual lifting rules

VII. Discuss and Demonstrate Safe Use of Conveyers
A. Watch for pinch points
B. Exercise caution when loading and unloading objects
C. Do not overload conveyers. Rollers may not move freely

VIII. Discuss and Demonstrate Safe Use of Chains and Slings
A. Storage area should be clean and dry
B. Watch for pinch points
C. Inspect for defects before using:
1. Chains
a. Wear
b. Stretch
c. Distortion
d. Nicks
e. Cracks
f. Gauges
2. Slings
a. Wear
b. Stretch
c. Distortion
d. Flat, Sling Spots

- D. Types
  - 1. Slings
    - a. Choker
    - b. Double Choker
    - c. Bridle
    - d. Basket
    - e. Double Basket

IX. Discuss and Demonstrate Safe Use of Chains and Slings

MFG-A5-LE
Lift Safely
Attachment 2: **MASTER** Laboratory Exercise

EXERCISE

1. Established standards for safety and conduct shall be followed.
2. Equipment required:
   Hand truck
   Conveyor
   Chains
   Sling
   Face shield
   Side shields
3. Exercises below must be taken in sequence. Instructor must confirm proficiency prior to student's progressing to next exercise.
   a. Practice manual lifting.
   b. Practice using hand truck to carry objects.
   c. Practice using powered truck to carry objects.
   d. Practice handling specific shapes.
   e. Practice lifting with slings.
   f. Practice lifting with chains.
4. Instructor will guide each exercise.
5. Instructor will grade each exercise.

MFG-A5-LA
Lift Safely
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-A6

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-A6

Subject: **Manufacturing Technology** **Time: 2 Hrs.**

Duty: **Practice Safety**
Task: Control Fire Hazards

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify what causes fires;
b. Explain how electrical equipment cause fire;
c. List good housekeeping rules that help prevent fires;
d. Know what to do in case of fire;
e. Identify the technician's responsibilities relative to fire safety;
f. List conditions required for fire to exist;
g. Name four classes of fires;
h List four typical causes of industrial fires described in the lesson;
i. Match the correct class extinguishers to a given fuel source; and,
j. Demonstrate proper use of a fire extinguisher.

Instructional Materials:

MASTER Handout (MFG-A6-HO)
MASTER Laboratory Exercise (MFG-A6-LE)
MASTER Laboratory Aid (MFG-A6-LA)
MASTER Self-Assessment
Dust Mask
Gloves
Face Shields
Side Shields
Outside space appropriate for controlled fire
Adequate extinguishers to use for practice
Emergency extinguishers for correct class of the fire
Reading assignment in 29 CFR 1910.155 and 29 CFR 1910.157

References:

29 CFR 1910.155

29 CFR-1910.157

First Aid Textbook, American National Red Cross, 17th and D Sts. NW., Washington DC 20006, Latest Edition

Approval Guide; Handbook of Property Conservation; and ***Loss Prevention Data,*** Factory Mutual Engineering Corporation of the Factory Mutual System, 1151 Boston-Providence Turnpike, Norwood, MA 02062, Latest Editions

Guide to Occupational Safety and Health Management, Firenze, Robert J., Kendall/Hunt Publishing Co., Dubuque, Iowa, Latest Edition

Supervisor's Guide to Human Relations, Hannaford, Earle S., Chicago, IL, National Safety Council, Latest Edition

IES Lighting Handbook (The Standard Lighting Guide) and ***Practice for Industrial Lighting (ANSI A11.1-1965),*** Illuminating Engineering Society, 345 East 47th St., New York, NY 10017, Latest Editions

Encyclopedia of Occupational Health and Safety and ***Loss Control,*** International Labor Organization, 666 11th St. NW., Washington, DC 20001, Latest Editions

A Safety Guidebook for Trades and Services, Van Nostrand Reinhold Co., New York, NY, Latest Edition

Fire Prevention Handbook; Fire Protection Guide on Hazardous Materials; Inspection Manual; National Electrical Code, Std. No. 70 (ANSI CI-1971); National Fire Codes (10 Volumes); and ***Standards and Recommended Practices,*** National Fire Protection Association, 470 Atlantic Ave., Boston, MA 02210, Latest Editions

Fire Fighting Equipment - 15m - Video Tape - (Akron), Latest Edition

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Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1	"Follow Safety Manuals and All Safety Regulations/Requirements"
MFG-A2	"Use Protective Equipment"
MFG-A3	"Follow Safe Operating Procedures for Hand and Machine Tools"
MFG-A4	"Maintain a Clean and Safe Work Environment"
MFG-A5	"Lift Safely"

Introduction:

This module will explain the most common causes of workplace fires on the job. You will learn what causes these fires and how to prevent them. It is your responsibility to use common sense and good housekeeping rules and make your job site a safer place to work.

Presentation Outline:

I. Identify Conditions Required for a Fire to Exist
  A. Fuel
  B. Oxygen
  C. Heat
II. Four Classes of Fire
  A. Ordinary combustibles
  B. Flammable liquids
  C. Electrical
  D. Combustible metals
III. List Four Typical Causes of Workplace Fires
  A. Careless smokers
  B. Electrical overloads
  C. Inadequate fire watch for welding and cutting operations
  D. Combustible dust in the atmosphere
IV. Improperly Maintained Electrical Equipment
  A. Worn or frayed insulation on wiring
  B. Incorrect fuse size
  C. Improper use of extension cords
  D. Improper grounding
  E. Overloaded conductors, motors, outlets of unattended heating equipment
V. Obey Smoking Rules
  A. Don't smoke near anything that can burn (paper, wood, flammables)
  B. Put cigarettes and matches out before throwing away
VI. Good Housekeeping Prevents Fires
  A. Keep motors and machine tools free of dust and grease
  B. Don't let belts and transmission shafts overheat
  C. Dispose of combustible scraps daily
  D. Restrict welding and cutting operations to separate fire proof rooms
  E. Check chemical labels
  F. Install smoke detectors
  G. Keep aisles, passages and fire doors clear
  H. Don't store oxygen cylinders near combustible materials
VII. Plan For an Emergency
  A. Know how to get out in case of fire

        1. Know escape route
        2. Practice evacuations
    B. Turn in the alarm
        1. Turn off equipment
        2. Close non-escape windows
        3. Evacuate by assigned routes if possible
    C. Know the location of fire extinguishers
        1. Know the classification of fire extinguisher
        2. Learn how to use fire extinguishers

VIII. Technician's Responsibility
    A. Each employer will have company specific rules
    B. Unless the technician is part of the company fire fighting crew or fire brigade
        1. Notify every one in the area to evacuate
        2. Get to a phone and notify appropriate department
        3. Something as simple as an ash tray or trash can can start fire that may be easily and safely extinguished. Appropriate department must be notified of the event
        4. Employees are responsible for keeping the workplace safe and for reporting unsafe conditions

IX. Demonstrate to Class How to Match the Correct Extinguishers for the Class of Fire

X. Demonstrate Proper Use of a Fire Extinguisher

Practical Application:

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-A7) dealing with material safety data sheets and controlling chemical hazards.

MFG-A6-HO
Control Fire Hazards
Attachment 1: MASTER Handout

Standards of performance:

Student shall demonstrate safe work habits in the work shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify what causes fires;
b. Explain how electrical equipment cause fire;
c. List good housekeeping rules that help prevent fires;
d. Know what to do in case of fire;
e. Identify the technician's responsibilities relative to fire safety;
f. List conditions required for fire to exist;
g. Name four classes of fires;
h List four typical causes of industrial fires described in the lesson;
i. Match the correct class extinguishers to a given fuel source; and,
j. Demonstrate proper use of a fire extinguisher.

Module Outline:

I. Identify Conditions Required for a Fire to Exist
    A. Fuel
    B. Oxygen
    C. Heat
II. Four Classes of Fire
    A. Ordinary combustibles
    B. Flammable liquids
    C. Electrical
    D. Combustible metals
III. List Four Typical Causes of Workplace Fires
    A. Careless smokers
    B. Electrical overloads

C. Inadequate fire watch for welding and cutting operations
D. Combustible dust in the atmosphere

IV. Improperly Maintained Electrical Equipment
- A. Worn or frayed insulation on wiring
- B. Incorrect fuse size
- C. Improper use of extension cords
- D. Improper grounding
- E. Overloaded conductors, motors, outlets of unattended heating equipment

V. Obey Smoking Rules
- A. Don't smoke near anything that can burn (paper, wood, flammables)
- B. Put cigarettes and matches out before throwing away

VI. Good Housekeeping Prevents Fires
- A. Keep motors and machine tools free of dust and grease
- B. Don't let belts and transmission shafts overheat
- C. Dispose of combustible scraps daily
- D. Restrict welding and cutting operations to separate fire proof rooms
- E. Check chemical labels
- F. Install smoke detectors
- G. Keep aisles, passages and fire doors clear
- H. Don't store oxygen cylinders near combustible materials

VII. Plan For an Emergency
- A. Know how to get out in case of fire
  - 1. Know escape route
  - 2. Practice evacuations
- B. Turn in the alarm
  - 1. Turn off equipment
  - 2. Close non-escape windows
  - 3. Evacuate by assigned routes if possible
- C. Know the location of fire extinguishers
  - 1. Know the classification of fire extinguisher
  - 2. Learn how to use fire extinguishers

VIII. Technician's Responsibility
- A. Each employer will have company specific rules
- B. Unless the technician is part of the company fire fighting crew or fire brigade
  - 1. Notify every one in the area to evacuate
  - 2. Get to a phone and notify appropriate department
  - 3. Something as simple as an ash tray or trash can can start fire that may be easily and safely extinguished. Appropriate department must be notified of the event
  - 4. Employees are responsible for keeping the workplace safe and for reporting unsafe conditions

IX. Demonstrate to Class How to Match the Correct Extinguishers for the Class of Fire

X. Demonstrate Proper Use of a Fire Extinguisher

Fire Extinguisher
Agent Characteristics

Suitable for use on what type of fire: B C

Agent Characteristics:
- Regular or Ordinary Dry Chemical
- Basically Sodium Bicarbonate
- Discharges a white cloud
- Leaves residue
- Non-freezing

Average Size - 1 to 30 lbs.
Horizontal Range - 5 to 20 ft.
Discharge Time - 8 to 25 sec.

Suitable for use on what type of fire: ABC or BC

Agent Characteristics:
- Multipurpose Dry Chemical
- Basically Ammonium Phosphate
- Discharges a yellow cloud
- Leaves residue
- Non-freezing
- Some extinguishers utilizing this agent do not have an "A" rating; however, they are designated as having "A" capability.

Average Size - 2 to 30 lbs.
Horizontal Range - 5 to 20 ft.
Discharge Time - 8 to 25 sec.

Suitable for use on what type of fire: B C

Agent Characteristics:
- Purple-K Dry Chemical
- Basically Potassium Bicarbonate
- Discharges a bluish cloud
- Leaves residue
- Non-freezing

Average Size - 2 to 30 lbs.
Horizontal Range - 5 to 20 ft.
Discharge Time - 8 to 25 sec.

Suitable for use on what type of fire: B C

Agent Characteristics:
- KCL Dry Chemical
- Basically Potassium Chloride
- Discharges a white cloud
- Leaves residue
- Non-freezing
- Potassium Chloride/Urea

Average Size - 2 to 30 lbs. (11 to 23)
Horizontal Range - 5 to 20 ft. (15 to 30)
Discharge Time - 8 to 25 sec. (20 to 31)

Suitable for use on what type of fire: B C

Agent Characteristics:
- Carbon Dioxide
- Basically an inert gas that discharges a cold white cloud
- Leaves no residue
- Non-freezing

Average Size - 2 ½ to 20 lbs.
Horizontal Range - 3 to 8 ft.
Discharge Time - 8 to 30 sec.

Suitable for use on what type of fire: B C

Agent Characteristics:
- Halogenated Agent
- Basically halogenated hydrocarbons
- Discharges a white vapor
- Leaves no residue
- Non-freezing

Average Size - 2 ½ lbs.
Horizontal Range - 4 to 8 ft.
Discharge Time - 8 to 10 sec.

Suitable for use on what type of fire: A

Agent Characteristics:
- Water
- Basically tap water
- Discharges in a solid or spray stream
- May contain corrosion inhibitor which leaves a yellow residue
- Protect from freezing

Average Size - 2 ½ gal.
Horizontal Range - 30 to 40 ft.
Discharge Time - 1 minute

Suitable for use on what type of fire: A

Agent Characteristics:
- Anti-Freeze Solution
- Basically a Calcium Chloride solution to prevent freezing
- Discharges a solid or spray stream
- Leaves residue
- Non freezing

Average Size - 2 ½ gal.
Horizontal Range - 30 to 40 ft.
Discharge Time - 1 minute

Suitable for use on what type of fire: A B

Agent Characteristics:
- Loaded Stream
- Basically an alkali-metal-salt solution to prevent freezing
- Discharges a solid or spray stream
- Leaves residue
- Non freezing

Average Size - 2 ½ gal.
Horizontal Range - 30 to 40 ft.
Discharge Time - 1 minute

Suitable for use on what type of fire: B

Agent Characteristics:

- Foam
- Basically a water and detergent
- Discharges a foamy solution
- After evaporation, leaves a powder residue
- Protect from freezing

Average Size - 18 oz.
Horizontal Range - 10 to 15 ft.
Discharge Time - 24 sec.

Suitable for use on what type of fire: D

Agent Characteristics:

- Dry Powder Special Compound
- Basically Sodium Chloride or Graphite materials
- Agent is discharged from an extinguisher in a solid stream or is applied with a scoop or shovel to smother combustible metal
- Leaves residue
- Non-freezing

Average Size - 30 lbs.
Horizontal Range - 5 to 20 ft.
Discharge Time - 25 to 30 sec.

MFG-A6-LE
Control Fire Hazards
Attachment 2: MASTER Laboratory Exercise

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1. Established standards for safety and conduct shall be followed.

2. Equipment required:
   Dust Mask;
   Gloves;
   Fire extinguishers;
   Face shield; and,
   Side shields.

3. Instructor must confirm proficiency prior to student progressing

4. Practice exercises
   A. Instructor will demonstrate proper usage of fire extinguishers
   B. Student shall practice using fire extinguishers

MFG-A6-LA
Control Fire Hazards
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name__________________________ Date_______________

MFG-A6
Control Fire Hazards
Self-Assessment

Circle the letter preceding the correct answer.

1. Fire is only possible when fuel, heat, and oxygen combine.
   a. True
   b. False

2. Careless smoking is the most common course of workplace fires.
   a. True
   b. False

3. Check chemical labels and MSDS so you don't store incompatible substances together.
   a. True
   b. False

4. The batteries in battery-operated smoke detectors should be replaced every year.
   a. True
   b. False

5. The first step to follow if you spot a fire is to turn in the alarm.
   a. True
   b. False

6. A fire extinguisher classified as A can be used to put out fires in wood or paper.
   a. True
   b. False

7. Water can be used to put out electrical fires.
   a. True
   b. False

8. If your clothing catches fire, stop, drop, and roll.
   a. True
   b. False

9. Because flammable liquid vapors evaporate, there is no need to remove clothing that has absorbed liquids.
   a. True
   b. False

10. You can treat minor burns with cool water.
   a. True
   b. False

11. Conditions required for a fire to exist:
   a. Fuel, Hydrogen, Heat
   b. Hydrogen, Oxygen, Fuel
   c. Heat, Hydrogen, Oxygen
   d. Fuel, Oxygen, Heat

12. Four classes of fire are:

____

____

____

____

13. List four typical causes of workplace fires:

____

____

____

____

14. A Class ___________ fire extinguisher is used for electrical fires.

15. A Class ___________ fire extinguisher is used for ordering combustibles fires.

Name____________________________ Date________________

MFG-A6
Control Fire Hazards
Self-Assessment Answer Key

1. A
2. B
3. A
4. A
5. B
6. A
7. B
8. A
9. B
10. A
11.
12.
13.
14.
15.

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-A7

Subject: **Manufacturing Technology** **Time: 8 Hrs.**

Duty: **Practice Safety**
Task: MSDS/Control Chemical Hazards

Objective(s):

Upon completion of this unit the student will be able to:

a. Define hazardous material;
b. Identify hazardous material;
c. Know the physical and chemical characteristics;
d. Describe storage, transportation, disposal of hazardous waste; and,
e. Explain material safety data sheets.

Instructional Materials:

MASTER Handout (MFG-A7-HO)
MASTER Laboratory Aid (MFG-A7-LA)
MASTER Self-Assessment

References:

OSHA General Industry Requirements, U. S. Government Printing Office, Latest Edition
Materials Safety Data Sheets for various chemicals

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1	"Follow Safety Manuals and All Safety Regulations/Requirements"
MFG-A2	"Use Protective Equipment"
MFG-A3	"Follow Safe Operating Procedures for Hand and Machine Tools"
MFG-A4	"Maintain a Clean and Safe Work Environment"
MFG-A5	"Lift Safely"
MFG-A6	"Control Fire Hazards"

Introduction:

Hazardous materials can cause immediate or long-term health problems if not managed properly. It is the responsibility of all persons involved with hazard waste to know the rules, the material, and how to handle the material properly.

Presentation Outline:

- I. Define Hazardous Materials According to the EPA
  - A. What makes a material hazardous?
    - 1. It is hazardous if it causes harm to people or environment
- II. Identify Hazardous Materials
  - A. Material Safety Data Sheets (MSDS)
    - 1. Companies that make and distribute hazardous substances must provide your company with a MSDS on hazardous material
    - 2. MSDS developed by OSHA
    - 3. MSDS is part of the Hazard Communication Standard or Right to Know regulation
    - 4. MSDS is an easy reference for information on hazardous substances
  - B. Information in MSDS
    - 1. What it is
    - 2. Who makes or sells it
    - 3. Where they are located
    - 4. Why it is hazardous
    - 5. How you can be exposed to the hazard
    - 6. Conditions that could increase the hazard
    - 7. How to handle the substance safely
    - 8. Protection to use while working with it
    - 9. What to do if exposed
    - 10. What to do if there is a spill or emergency
- III. Know the Chemical and Physical Characteristics
  - A. Corrosive
    - 1. Burns skin or eyes on contact
  - B. Explosive
  - C. Flammable
    - 1. Catches fire easily
  - D. Radioactive
  - E. Reactive
    - 1. Burns, explodes
    - 2. Releases toxic vapors
  - F. Toxic
    - 1. Causes illness or possibly death

IV. Describe Storage, Transportation, Disposal
    A. Resource Conservation and Recovery Act (RCRA)
        1. Designed to reduce hazards of waste by tracking and regulating the substance
        2. Method used is called from cradle (creation) to grave (disposal)
        3. Tells what hazards are and how to keep track of them
        4. Sets up rules for handling wastes
        5. Provides strict documentation system to track them
    B. Your employer may have to report to the Environmental Protection Agency (EPA) on how the company is meeting the RCRA responsibilities
    C. The law requires companies that treat, store, or dispose of hazardous wastes to:
        1. Must have a permit
        2. Identify and analyze new hazardous waste
        3. Provide a secure facility that keeps unauthorized people out
        4. Inspect the facility regularly
        5. Have a contingency plan for fire, explosion, and spills
        6. Practice emergency response for fire, explosion, spills
        7. Provide proper protective clothing and equipment
        8. Maintain EPA-required records

Practical Application:

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-B1) dealing with performing basic arithmetic functions.

MFG-A7-HO

MSDS/Control Chemical Hazards

Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Define hazardous material;
b. Identify hazardous material;
c. Know the physical and chemical characteristics;
d. Describe storage, transportation, disposal of hazardous waste; and,
e. Explain material safety data sheets.

Module Outline:

I. Define Hazardous Materials According to the EPA
   A. What makes a material hazardous?
      1. It is hazardous if it causes harm to people or environment
II. Identify Hazardous Materials
   A. Material Safety Data Sheets (MSDS)
      1. Companies that make and distribute hazardous substances must provide your company with a MSDS on hazardous material
      2. MSDS developed by OSHA
      3. MSDS is part of the Hazard Communication Standard or Right to Know regulation
      4. MSDS is an easy reference for information on hazardous substances
   B. Information in MSDS
      1. What it is
      2. Who makes or sells it
      3. Where they are located
      4. Why it is hazardous
      5. How you can be exposed to the hazard
      6. Conditions that could increase the hazard
      7. How to handle the substance safely
      8. Protection to use while working with it
      9. What to do if exposed
      10. What to do if there is a spill or emergency
III. Know the Chemical and Physical Characteristics
   A. Corrosive
      1. Burns skin or eyes on contact
   B. Explosive
   C. Flammable

        1. Catches fire easily
    D. Radioactive
    E. Reactive
        1. Burns, explodes
        2. Releases toxic vapors
    F. Toxic
        1. Causes illness or possibly death

IV. Describe Storage, Transportation, Disposal
    A. Resource Conservation and Recovery Act (RCRA)
        1. Designed to reduce hazards of waste by tracking and regulating the substance
        2. Method used is called from cradle (creation) to grave (disposal)
        3. Tells what hazards are and how to keep track of them
        4. Sets up rules for handling wastes
        5. Provides strict documentation system to track them
    B. Your employer may have to report to the Environmental Protection Agency (EPA) on how the company is meeting the RCRA responsibilities
    C. The law requires companies that treat, store, or dispose of hazardous wastes to:
        1. Must have a permit
        2. Identify and analyze new hazardous waste
        3. Provide a secure facility that keeps unauthorized people out
        4. Inspect the facility regularly
        5. Have a contingency plan for fire, explosion, and spills
        6. Practice emergency response for fire, explosion, spills
        7. Provide proper protective clothing and equipment
        8. Maintain EPA-required records

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name____________________________ Date________________

MFG-A7
MSDS/Control Chemical Hazards
Self-Assessment

Circle the letter preceding the correct answer.

1. The law requires companies that treat, store, or dispose of hazardous wastes to __________.
   a. Have a permit
   b. Give notice before dumping
   c. Have OSHA personnel on site at all times
   d. All of the above

2. Your employer may have to report to the _________ on how the company is meeting the RCRA responsibility.
   a. OSHA
   b. EPA
   c. RCRA
   d. Local authorities

3. The EPA requires paperwork that tracks hazardous waste from _________ to ____________.
   a. Company to company
   b. State to state
   c. Cradle to grave
   d. Manufacturer to company

4. The key pieces of information in the manifest are ____________.
   a. Manifest document number
   b. Name, address, phone numbers, EPA ID number of generator
   c. Description of the hazardous waste
   d. All of the above

5. Who must sign the manifest and keep a copy?
   a. Only the manufacture
   b. Only the shipper
   c. Only those who dispose of the waste
   d. Everyone who handles the waste

6. A material safety data sheet tells you the chemical's _________.
   a. Market value
   b. Color
   c. Physical and chemical characteristics
   d. All of the above

7. If properly wrapped, hazardous waste ___________________.
   a. May be disposed of at public dumps
   b. Must be disposed of according to the EPA guidelines
   c. Dumped on private property
   d. All of the above

8. MSDS stands for ____________.
   a. Material safety data sheet
   b. Military secret dumping site
   c. Mine safety division storage
   d. Material safe disposal site

9. OSHA developed the MSDS as part of ____________.
   a. Hazard communication standard
   b. Right-to-know regulations
   c. Both A & B
   d. Neither A nor B

10. The ____________ part of the label can either indicate a specific hazard or what personal protective equipment should be used.
   a. White
   b. Red
   c. Triangle
   d. Cross-hairs

MFG-A7
MSDS/Control Chemical Hazards
Self-Assessment Answer Key

1. a
2. b
3. c
4. d
5. d
6. c
7. b
8. a
9. c
10. a

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

Duty B

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B1

Subject: **Manufacturing Technology** **Time: 1 Hr.**

Duty: **Apply Mathematical Concepts**
Task: Perform Basic Arithmetic Functions

Objective(s):

Upon completion of this unit the student will be able to:

a. Add, subtract, multiply, and divide whole numbers;
b. Add, subtract, multiply, and divide fractions; and,
c. Add, subtract, multiply, and divide decimals.

Instructional Materials:

MASTER Handout (MFG-B1-HO)
MASTER Laboratory Aid (MFG-B1-LA)
MASTER Self-Assessment

References:

Student's Shop Reference Handbook, Industrial Press, Latest Edition, Unit on Mathematics
Mathematics for Machine Technology, R. D. Smith, Delmar Publishers, Inc., Latest Edition, Units 1-12

Student Preparation:

Introduction:

Mathematics is called the "Queen of Sciences" for a definite reason. In the modern world, almost nothing can be done without it. Fundamental to success in all mathematics is a thorough and complete understanding of the four basic functions of arithmetic: Addition, Subtraction, Multiplication, and Division. Technicians must perform all functions of arithmetic on a daily basis and with complete confidence. This lesson is designed to dust off all your old memories and to permit you to see that solid base of arithmetic which you must surely have to progress.

Presentation Outline:

I. Add, Subtract, Multiply, and Divide Whole Numbers
  A. Addition of whole numbers
  B. Subtraction of whole numbers
  C. Multiplication of whole numbers
  D. Division of whole numbers
  E. Hierarchy of operations
II. Add, Subtract, Multiply, and Divide Fractions
  A. Common operations
    1. Least common denominator
    2. Factoring for reduction
    3. Improper fractions
    4. Mixed numbers
  B. Addition
  C. Subtraction
  D. Multiplication
  E. Division
III. Add, Subtract, Multiply, and Divide Decimals
  A. Aligning the decimal (addition and subtraction)
  B. Moving the decimal
    1. In division, move the decimal to the right until it is eliminated in the divisor. Move the decimal the same number of places to the right in the dividend.
    2. In multiplication, count the total number of decimals places in the two numbers being multiplied. Beginning in the product at the *right-most digit*, count off the same number of places and place the decimal.

Practical Application:

The students shall demonstrate a working knowledge of the four basic operations of arithmetic and an ability to reduce fractions.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-B2) dealing with the conversion of fractions and decimals.

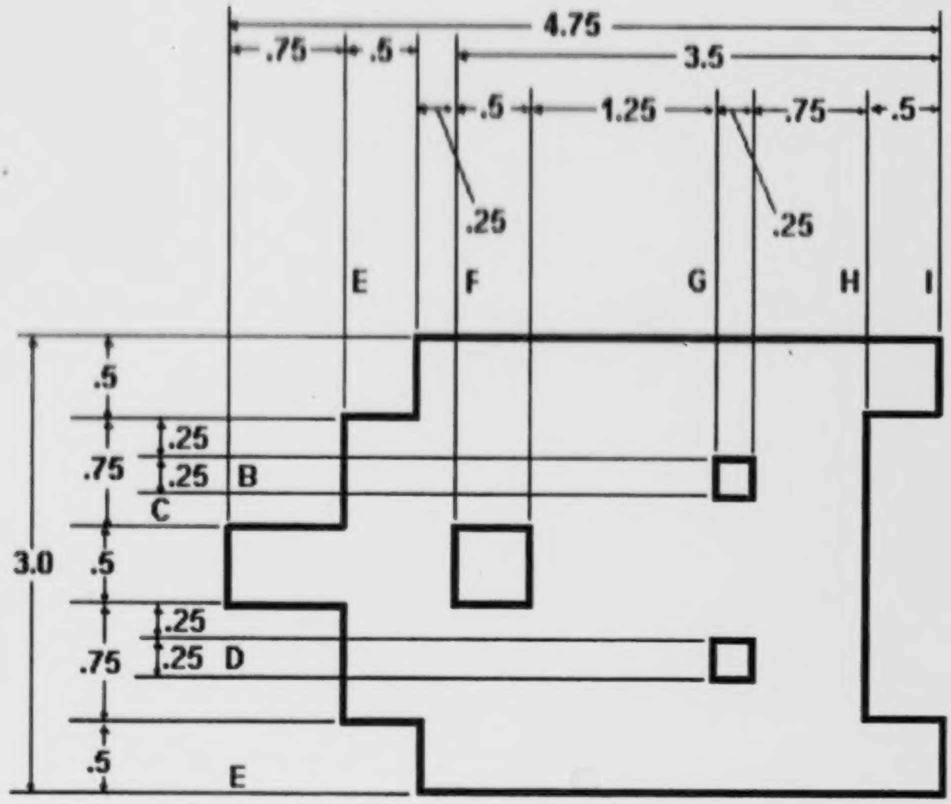
MFG-B1-HO
Perform Basic Arithmetic Functions
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Add, subtract, multiply, and divide whole numbers;
- b. Add, subtract, multiply, and divide fractions; and,
- c. Add, subtract, multiply, and divide decimals.

Module Outline:

- I. Add, Subtract, Multiply, and Divide Whole Numbers
  - A. Addition of whole numbers
  - B. Subtraction of whole numbers
  - C. Multiplication of whole numbers
  - D. Division of whole numbers
  - E. Hierarchy of operations
- II. Add, Subtract, Multiply, and Divide Fractions
  - A. Common operations
    - 1. Least common denominator
    - 2. Factoring for reduction
    - 3. Improper fractions
    - 4. Mixed numbers
  - B. Addition
  - C. Subtraction
  - D. Multiplication
  - E. Division
- III. Add, Subtract, Multiply, and Divide Decimals
  - A. Aligning the decimal (addition and subtraction)
  - B. Moving the decimal
    - 1. In division, move the decimal to the right until it is eliminated in the divisor. Move the decimal the same number of places to the right in the dividend.
    - 2. In multiplication, count the total number of decimals places in the two numbers being multiplied. Beginning in the product at the *right-most digit,* count off the same number of places and place the decimal.


4.75
.75
.5
3.5
.5
1.25
.75
.5
.25
.25
E
F
G
H
I
.5
.25
.75
.25
B
C
3.0
.5
.25
.75
.25
D
.5
E

Name________________________ Date______________

MFG-B1
Perform Basic Arithmetic Functions
Self-Assessment

Show all work.

Reduce the following fractions:

1. 4/64 ______________________________
2. 6/4 ______________________________
3. 6/16 ______________________________
4. 12/32 ______________________________
5. 9/16 ______________________________

Perform the indicated operations:

6. 3.25 + 2.375 = ______________________________
7. 15/32 + 1/4 = ______________________________
8. 15/32 - 1/4 = ______________________________
9. 9/64 + 9/32 = ______________________________
10. 1/4 x 3/4 = ______________________________
11. 1/4 ÷ 3/4 = ______________________________
12. 0.625 x 1/4 = ______________________________
13. 0.625 + 1.125 = ______________________________
14. 1.125 - 0.75 = ______________________________
15. 1.25/1.5 = ______________________________

For Questions 16 through 25, use the dimensional notations on the drawing.

16. What is the distance between Line A and Line B? ____________

17. What is the distance between Line B and Line C? ____________

18. What is the distance between Line B and Line D? ____________

19. What is the distance between Line C and Line E? ____________

20. What is the distance between Line C and Line D? ____________

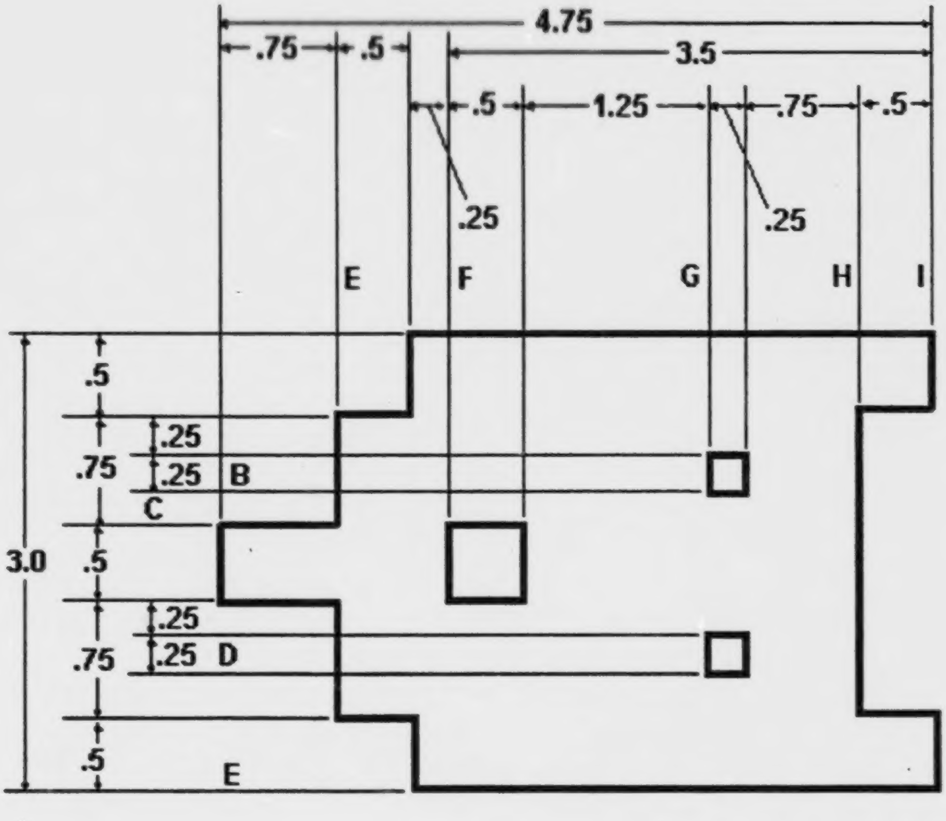
21. What is the distance between Line E and Line F? ____________

22. What is the distance between Line F and Line G? ____________

23. What is the distance between Line F and Line I? ____________

24. What is the distance between Line G and Line H? ____________

25. What is the distance between Line I and Line E? ____________


4.75
.75
.5
3.5
.5
1.25
.75
.5
.25
.25
E
F
G
H
I
.5
.25
.75
.25
B
C
3.0
.5
.25
.75
.25
D
.5
E

MFG-B1
Perform Basic Arithmetic Functions
Self-Assessment Answer Key

1. 1/16
2. 1 ½
3. 3/8
4. 3/8
5. 9/16
6. 5.625
7. 23/32
8. 7/32
9. 27/64
10. 3/16
11. 1/3
12. 0.156
13. 1.75
14. 0.375
15. 0.833
16. 0.75
17. 0.25
18. 1.25
19. 1.75
20. 1.0
21. 0.75
22. 1.75
23. 3.25
24. 1.0
25. 4.0

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B2

Subject: **Manufacturing Technology** **Time: 2 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Convert Fractions/Decimals

Objective(s):

Upon completion of this unit the student will be able to:
a. Write fractions as decimals;
b. Write decimals as fractions; and,
c. Use fractions and decimals interchangeably.

Instructional Materials:

MASTER Handout (MFG-B2-HO)
MASTER Self-Assessment

References:

Student's Shop Reference Handbook, Industrial Press, Latest Edition, Unit on Mathematics
Mathematics for Machine Technology, R. D. Smith, Delmar Publishers, Inc., Latest Edition, Unit 8: Rounding Decimal Fractions and Equivalent Decimal and Common Fractions

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Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-B1 "Perform Basic Arithmetic Functions"

Introduction:

Unfortunately, nothing is standard. One tool has decimal fractions on its indicators; the next has increments of 1/64th inch. One drafter prefers common fractions; the next marks off everything in decimals. It's enough to make a grown technician cry! Of course, on the shop floor, you cannot carry around a beach towel to catch all the tears. All this confusion leads to only one conclusion: The successful technician easily converts decimal fractions to common fractions, and *vice versa.*

Presentation Outline:

- I. Write Fractions as Decimals
  - A. Understand and be able to use equivalent fractions
  - B. Write fractions in lowest terms
  - C. Understand improper fractions and mixed numbers
  - D. Be able to write fractions as decimals by performing the indicated division
- II. Write Decimals as Fractions
  - A. Understand the place value in decimals
  - B. Understand how to find the fraction or mixed number equivalent of decimals by writing the digits over the place value and reducing this to the lowest terms
- III. Use Fractions and Decimals Interchangeably
  - A. Understand how fractions and decimals can be used interchangeably to represent the same value
  - B. Be able to determine the best representation, fraction or decimal, for a given industrial problem
- IV. Common Technical Conversions
  - A. These are the six most important conversions from denominative fractions to decimal fractions
    1. 1/64 is *about* .016 (sixteen thousandths)
    2. 1/32 is *about* .031 (thirty-one thousandths)
    3. 1/16 is *about* .062 (sixty-two thousandths)
    4. 1/8 is .125 (one hundred twenty-five thousandths)
    5. 1/4 is .250 (two hundred fifty thousandths)
    6. 1/2 is .500 (five hundred thousandths)
  - B. The trick to quickly converting these fractions is to think of them just like they were building blocks. For example, how much is 11/16 inch in thousandths? 11/16 is actually 1/2 + 1/8 + 1/16, so it is also .500 + .125 + .062, or .687.
  - C. If you, the technician, will learn the six basic conversions listed above, then you will have won half the battle of fractional conversions.
  - D. It is also helpful to think in thousandths. Don't think of .5 as one-half or five tenths, think of it as 500 thousandths. Thinking this way will automatically align the decimal places for you and allow you to quickly add and subtract measurements.
  - E. By the same token, it is easier to think in 64ths than it is to carry around all those fractions in your head. Converting fractions can cause errors because it is another step. Since the assumed standard of tolerance in binary fractions is 1/64 inch, *think that way*. One-half becomes 32/64; one-eighth, 8/64. The arithmetic almost does itself when all the fractions in your head have common denominators.

Practical Application:

Students will be able to convert fractions and decimals as needed to conduct operations encountered in the manufacturing industry, such as interpreting denominative blueprints for production on decimal machines and choosing the proper drill bits for decimal holes. The student should understand that this is a fairly common occurrence in the shop.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-B3) dealing with the conversion of Metric/English measurements.

MFG-B2-HO
Convert Fractions/Decimals
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Write fractions as decimals;
- b. Write decimals as fractions; and,
- c. Use fractions and decimals interchangeably.

Module Outline:

- I. Write Fractions as Decimals
  - A. Understand and be able to use equivalent fractions
  - B. Write fractions in lowest terms
  - C. Understand improper fractions and mixed numbers
  - D. Be able to write fractions as decimals by performing the indicated division
- II. Write Decimals as Fractions
  - A. Understand the place value in decimals
  - B. Understand how to find the fraction or mixed number equivalent of decimals by writing the digits over the place value and reducing this to the lowest terms
- III. Use Fractions and Decimals Interchangeably
  - A. Understand how fractions and decimals can be used interchangeably to represent the same value
  - B. Be able to determine the best representation, fraction or decimal, for a given industrial problem
- IV. Common Technical Conversions
  - A. These are the six most important conversions from denominative fractions to decimal fractions
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    2. 1/32 is *about* .031 (thirty-one thousandths)
    3. 1/16 is *about* .062 (sixty-two thousandths)
    4. 1/8 is .125 (one hundred twenty-five thousandths)
    5. 1/4 is .250 (two hundred fifty thousandths)
    6. 1/2 is .500 (five hundred thousandths)
  - B. The trick to quickly converting these fractions is to think of them just like they were building blocks. For example, how much is 11/16 inch in thousandths? 11/16 is actually 1/2 + 1/8 + 1/16, so it is also .500 + .125 + .062, or .687.
  - C. If you, the technician, will learn the six basic conversions listed above, then you will have won half the battle of fractional conversions.

D. It is also helpful to think in thousandths. Don't think of .5 as one-half or five tenths, think of it as 500 thousandths. Thinking this way will automatically align the decimal places for you and allow you to quickly add and subtract measurements.

E. By the same token, it is easier to think in 64ths than it is to carry around all those fractions in your head. Converting fractions can cause errors because it is another step. Since the assumed standard of tolerance in binary fractions is 1/64 inch, *think that way*. One-half becomes 32/64; one-eighth, 8/64. The arithmetic almost does itself when all the fractions in your head have common denominators.

Name______________________________ Date_________________

MFG-B2
Convert Fractions/Decimals
Self-Assessment

Convert the following to decimal fractions:

1. 1/8 ______________________________
2. 1/16 ______________________________
3. 1/4 ______________________________
4. 1/32 ______________________________
5. 1/64 ______________________________

Reduce the following fractions to the lowest denominator:

6. 4/16 ______________________________
7. 12/32 ______________________________
8. 20/64 ______________________________
9. 4/8 ______________________________
10. 9/16 ______________________________

Using the "Building Blocks," give the decimal equivalents of the following:

11. 13/16 ______________________________
12. 35/64 ______________________________
13. 5/16 ______________________________
14. 5/32 ______________________________
15. 9/32 ______________________________

Using the Drill Bit Table below, choose the best bit to drill the designated holes.

Drill Bits Available:

1/64	1/32	1/16	3/32	7/64	1/8
5/32	11/64	1/4	1/2	5/8	13/64

Holes to be drilled:

16. .125" ______________________

17. .5" ______________________

18. .875" ______________________

19. .0625" ______________________

20. .094" ______________________

21. .250" ______________________

22. .625" ______________________

MFG-B2
Convert Fractions/Decimals
Self-Assessment Answer Key

1. .125
2. .062
3. .25
4. .031
5. .016
6. 1/4
7. 3/8
8. 5/16
9. 1/2
10. 9/16 (This fraction is unreduceable.)
11. .5 + .25 + .062 = .812
12. .5 + .031 +.016 = .547
13. .25 + .062 = .312
14. .125 + .031 = .156
15. .25 + .031 = .56
16. 1/8
17. 1/2
18. 5/8
19. 1/16
20. 3/32
21. 1/4
22. 3/8

MFG-B3

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B3

Subject: **Manufacturing Technology** **Time: 2 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Convert Metric/English (Customary or English) Measurements

Objective(s):

Upon completion of this unit the student will be able to:

a. Make inch, foot, and yard (English) measurements using rulers, calipers, and height gages;
b. Make millimeter, centimeter, meter (metric) measurements using metric rulers, calipers, and height gages; and,
c. Use English and metric measurements interchangeably.

Instructional Materials:

Rulers, calipers, and height gages marked in both English and metric units of measurement
Table of English/metric conversions (provided on Self-Assessment)
Calculators for students
MASTER Handout (MFG-B3-HO)
MASTER Self-Assessment

References:

Student's Shop Reference Handbook, Industrial Press, Latest Edition, Unit on Mathematics
Mathematics for Machine Technology, R. D. Smith, Delmar Publishers, Inc., Latest Edition, Section 2, Linear Measurement: English and Metric

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-B1 "Perform Basic Arithmetic Functions"

Introduction:

An experienced machinist will often have to take the time to plan his/her own work as well as the work of others on occasion so that manufacturing operations can be performed in the most efficient manner. Understanding English and metric measurements of length and being able to use the two units of measurement interchangeably will help in accurate planning of work and in the preparation of machines and tools which will yield increased production, better quality, less scrap/rework, and more time to concentrate on manufacturing quality and productivity improvements. Many situations a machinist will face require basic understanding of both units of measure as applied to the industrial setting. To be better machinists, and incidentally better employees, good technicians will understand and be able to use English and metric measurements of length interchangeably.

Presentation Outline:

I. Make Inch, Foot, and Yard (English) Measurements Using Rulers, Calipers, and Height Gages
    A. Know the units of length, their symbols and relationships
    B. Be able to convert from one unit of length to another
    C. Be able to choose the degree of accuracy desired when making length measurements
    D. Be able to measure to the nearest 1/64 inch using rulers, and to the nearest .001" using calipers and height gages
II. Write Millimeter, Centimeter, and Meter (Metric) Measurements Using Metric Rulers, Calipers, and Height Gages
    A. Know the metric units of length, their symbols and relationships
    B. Be able to convert from one metric unit of length to another
    C. Be able to choose the degree of accuracy desired when making metric unit of length measurements
    D. Be able to measure to the nearest centimeter or millimeter using metric rulers, calipers, and height gages
III. Convert Metric/English Units of Length
    A. Know how to convert metric to English units using a conversion factors table
    B. Know how to convert English units to metric units using a conversion factors table

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Practical Application:

Students will be able to make English and metric length measurements, and be able to convert the measurements using a Metric-English Linear Equivalents (Conversion Factors) Table as needed to conduct operations encountered in the manufacturing industry.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-B4) dealing with performing basic algebraic operations.

MFG-B3-HO
Convert Metric/English (Customary or English) Measurements
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Make inch, foot, and yard (English) measurements using rulers, calipers, and height gages;
b. Make millimeter, centimeter, meter (metric) measurements using metric rulers, calipers, and height gages; and,
c. Use English and metric measurements interchangeably.

Module Outline:

I. Make Inch, Foot, and Yard (English) Measurements Using Rulers, Calipers, and Height Gages
    A. Know the units of length, their symbols and relationships
    B. Be able to convert from one unit of length to another
    C. Be able to choose the degree of accuracy desired when making length measurements
    D. Be able to measure to the nearest 1/64 inch using rulers, and to the nearest .001" using calipers and height gages
II. Write Millimeter, Centimeter, and Meter (Metric) Measurements Using Metric Rulers, Calipers, and Height Gages
    A. Know the metric units of length, their symbols and relationships
    B. Be able to convert from one metric unit of length to another
    C. Be able to choose the degree of accuracy desired when making metric unit of length measurements
    D. Be able to measure to the nearest centimeter or millimeter using metric rulers, calipers, and height gages
III. Convert Metric/English Units of Length
    A. Know how to convert metric to English units using a conversion factors table
    B. Know how to convert English units to metric units using a conversion factors table

Name______________________________ Date________________

MFG-B3
Convert Metric/English Measurements
Self-Assessment

Circle the letter preceding the correct answer.

Convert the following metric measurements to English equivalents using the following conversion factors:

1 millimeter (mm) = 0.03937 inch (in)
1 centimeter (cm) = 0.3937 inch (in)
1 meter (m) = 39.37 inches (in)
1 meter (m) = 3.2808 feet (ft)

1. 5 mm = _____ in
   - a. 0.19685
   - b. 1.565
   - c. 0.6875
   - d. 2.675

2. 2 cm = _____ in
   - a. 0.875
   - b. 0.7874
   - c. 6875
   - d. 2.175

3. 2 m = _____ ft
   - a. 5
   - b. 6.958
   - c. 6.5616
   - d. 8

4. 20 m = _____ ft.
   - a. 45
   - b. 65.616
   - c. 40
   - d. 25

5. 20 cm = _____ in
   - a. 2.0
   - b. 1.5
   - c. 7.874
   - d. 3.0

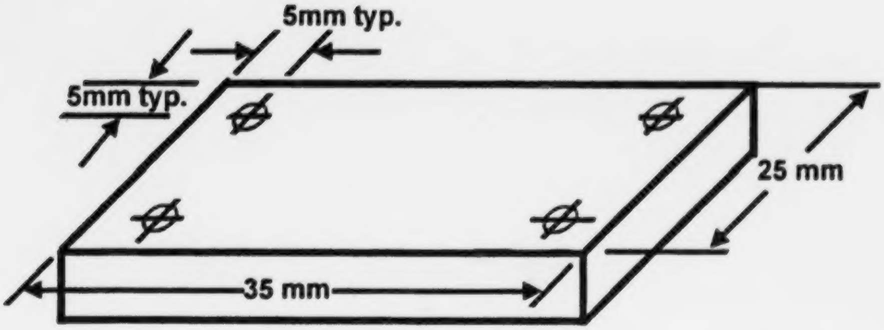
Write the following English units as metric units using the following conversion factors:

1 inch (in) = 25.4 millimeters (mm)
1 inch (in) = 2.54 centimeters (cm)
1 foot (ft) = 0.3048 meter (m)

6. 2 in = _____ mm
   - a. 50.9
   - b. 65
   - c. 79
   - d. 19

7. 2 in = _____ cm
   - a. 15
   - b. 24
   - c. 5.09
   - d. 150

8. 10 ft = _____ m
   - a. 3.048
   - b. 38
   - c. 4
   - d. 1.4


5mm typ.
5mm typ.
25 mm
35 mm

9. Given the above drawing and a milling machine graduated in thousands of an inch, how would you calculate the hole locations to be able to make this part?

MFG-B3
Convert Metric/English Measurements
Self-Assessment Answer Key

1. A
2. B
3. C
4. B
5. C
6. A
7. C
8. A

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B4

Subject: **Manufacturing Technology** **Time: 8 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Perform Basic Algebraic Operations

Objective(s):

Upon completion of this unit the student will be able to:
a. Understand basic algebraic symbols and expressions; and,
b. Use equations to solve problems.

Instructional Materials:

Calculators for Students
MASTER Handout (MFG-B4-HO)
MASTER Self-Assessment

References:

Mathematics for Machine Technology, R. D. Smith, Delmar Publishing, Latest Edition

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-B1 "Perform Basic Arithmetic Functions"

Introduction:

Algebra is critical in the workplace because technicians frequently encounter situations that include unknown quantities. The purpose of algebra is to provide a means of mathematically describing any situation so that those unknown quantities can be certainly deduced. In other words, algebra is *not* a set series of formulas; rather, it is a *way of thinking about numbers.* As a technician, you will daily take rods and bars of metal and form them into sometimes intricate parts on the lathe or the milling machine. Algebra is the lathe of mathematics—with its processes, you can manipulate numbers as easily as you work bronze or aluminum. Look past the fancy names that have been stuck on the processes and rules of algebra and look at what they *say and do* in common language. Many experienced machinists do algebra every day, *in their heads,* and never even realize what they are doing!

Presentation Outline:

I. Understand Basic Algebraic Symbols and Expressions
A. Symbols
1. Addition "+"
2. Subtraction "-"
3. Multiplication "·"; "x", and parentheses
4. Division "÷" and "/"
5. Exponents are generally limited to the term "square" in linear measurements. This is the "^{2}" notation.

B. Expressions
1. Sum: the total amount resulting from addition
2. Difference: the remaining amount resulting from subtraction
3. Product: the total amount resulting from multiplication
4. Exponent: a superscript which indicates the number of times a quantity is multiplied by itself
5. Quotient: the amount resulting from division

II. Use a Few Easy-to-Remember Rules to Solve Equations
A. *P*lease *E*xcuse *My* *D*ear *A*unt *S*ue indicates the order in which equations are solved. Each letter shows one of the algebraic notations or functions: Parentheses, Exponents, Multiply, Divide, Add, Subtract.
1. In the expression $(x - y)^2 + 2x^2 - y^2$, the *p*arentheses, which must be worked first, indicate that y must be subtracted from x. Since we don't know what x and y are, we can't do that, and must move on.
2. The next step is to square the term $(x - y)$, as indicated by the *e*xponent. This gives us $x^2 - 2xy + y^2 + 2x^2 - y^2$.
3. There is no operable *m*ultiplication or *d*ivision in this expression, so we move on.
4. Grouping all the like terms to make seeing the answer easier, we have $x^2 + 2x^2 + y^2 - y^2 - 2xy$.
5. *A*dding, we now have $3x^2 + y^2 - y^2 - 2xy$.
6. *S*ubtracting, which is the final step, renders $3x^2 - 2xy$.

B. *FOIL* gives the order in which you multiply the terms in expressions. Let us go back to squaring (multiplying by itself) $(x - y)$ from the expression above.
1. *F*irst terms first, so, in $(x - y)(x - y)$, multiply the two x's first. This give us x^2.
2. *O*utside terms come next, so multiply the first x by the second y. This gives us $x^2 - xy$.
3. *I*nside terms come next, so multiply the first y by the second x. This gives us $x^2 - xy - xy$.

4. *L*ast terms are last, so multiply the two y's. This gives us a complete (if complex) $x^2 - xy - xy + y^2$.
5. Simplifying gives us the expression $x^2 - 2xy + y^2$.

C. Thinking about algebra can be daunting to almost anybody, but once you see that algebra is just juggling done with numbers and with a lot of two-dollar words stuck all over it, algebra becomes rather simple. Remember, algebra is just taking the four basic mathematic operations (addition, subtraction, multiplication, and division) and using them to find out something that you didn't know to start with.

D. Word problems are what you will encounter every day in the shop. Someone will tell you to get so much material and make so many parts from it. As you progress in skill, they will tell you to get such-and-such material and make so many parts from it. Your mastery of basic algebra will make these problems easy to solve.

Practical Application:

Students will be able to perform basic algebraic operations as needed to solve problems and to conduct operations encountered in the manufacturing industry. Taper calculations, thread calculations, and rpm calculations are all based on algebra.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-B5) dealing with practical geometry.

MFG-B4-HO
Perform Basic Algebraic Operations
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Understand basic algebraic symbols and expressions; and,

b. Use equations to solve problems.

Module Outline:

I. Understand Basic Algebraic Symbols and Expressions
   A. Symbols
      1. Addition "+"
      2. Subtraction "-"
      3. Multiplication "·"; "x", and parentheses
      4. Division "÷" and "/"
      5. Exponents are generally limited to the term "square" in linear measurements. This is the "^{2}" notation.
   B. Expressions
      1. Sum: the total amount resulting from addition
      2. Difference: the remaining amount resulting from subtraction
      3. Product: the total amount resulting from multiplication
      4. Exponent: a superscript which indicates the number of times a quantity is multiplied by itself
      5. Quotient: the amount resulting from division

II. Use a Few Easy-to-Remember Rules to Solve Equations
   A. *P*lease *E*xcuse *M*y *D*ear *A*unt *S*ue indicates the order in which equations are solved. Each letter shows one of the algebraic notations or functions: Parentheses, Exponents, Multiply, Divide, Add, Subtract.
      1. In the expression $(x - y)^2 + 2x^2 - y^2$, the *p*arentheses, which must be worked first, indicate that y must be subtracted from x. Since we don't know what x and y are, we can't do that, and must move on.
      2. The next step is to square the term $(x - y)$, as indicated by the *e*xponent. This gives us $x^2 - 2xy + y^2 + 2x^2 - y^2$.
      3. There is no operable *m*ultiplication or *d*ivision in this expression, so we move on.
      4. Grouping all the like terms to make seeing the answer easier, we have $x^2 + 2x^2 + y^2 - y^2 - 2xy$.
      5. *A*dding, we now have $3x^2 + y^2 - y^2 - 2xy$.
      6. *S*ubtracting, which is the final step, renders $3x^2 - 2xy$.

B. *FOIL* gives the order in which you multiply the terms in expressions. Let us go back to squaring (multiplying by itself) $(x - y)$ from the expression above.

1. *F*irst terms first, so, in $(x - y)(x - y)$, multiply the two x's first. This give us x^2.
2. *O*utside terms come next, so multiply the first x by the second y. This gives us $x^2 -xy$.
3. *I*nside terms come next, so multiply the first y by the second x. This gives us $x^2 - xy - xy$.
4. *L*ast terms are last, so multiply the two y's. This gives us a complete (if complex) $x^2 - xy - xy + y^2$.
5. Simplifying gives us the expression $x^2 - 2xy + y^2$.

C. Thinking about algebra can be daunting to almost anybody, but once you see that algebra is just juggling done with numbers and with a lot of two-dollar words stuck all over it, algebra becomes rather simple. Remember, algebra is just taking the four basic mathematic operations (addition, subtraction, multiplication, and division) and using them to find out something that you didn't know to start with.

D. Word problems are what you will encounter every day in the shop. Someone will tell you to get so much material and make so many parts from it. As you progress in skill, they will tell you to get such-and-such material and make so many parts from it. Your mastery of basic algebra will make these problems easy to solve.

Name____________________________ Date________________________

MFG-B4
Perform Basic Algebraic Operations
Self-Assessment

Answer the following questions by circling the most correct answer.

1. The technician is given an order for 100 six-inch bars of 1" CRS. If the company stores its 1" CRS in ten-foot lengths, how many lengths of 1" CRS must the technician obtain in order to complete the job? You may assume that there is no waste.
   A. Five
   B. Ten
   C. Twenty
   D. Twenty-five
   E. None of the above answers is correct.

2. The technician is now told to turn all those six-inch bars down from 1" to 7/8". How much must the technician take off each bar?
   A. 1/16"
   B. 2/16"
   C. 3/16"
   D. 4/16"
   E. None of the above answers is correct.

3. A technician must bore three holes in a 90° arc. The holes must be equally spaced along the arc, and Hole 1 is at the baseline (0°). What is the angle between Hole 1 and Hole 2?
   A. 15°
   B. 30°
   C. 45°
   D. 60°
   E. None of the above answers is correct.

4. A technician must bore three holes in a 90° arc. The holes must be equally spaced along the arc, and Hole 1 is at the baseline (0°). What is the angle between Hole 1 and Hole 3?
   A. 15°
   B. 30°
   C. 45°
   D. 60°
   E. None of the above answers is correct.

5. From a twelve-inch bar, the technician must cut two pieces such that one piece is twice as long as the other. What are the lengths of the resultant bars?
   A. 2" & 4"
   B. 3" & 6"
   C. 4" & 8"
   D. 5" & 10"
   E. None of the above answers is correct.

6. Whitworth threads require that the depth of the thread be .64 of the length of the pitch of the thread. If the thread pitch is 1/8 inch, what is the depth of the threads?
   A. .195 inch
   B. 5.12 inch
   C. .08 inch
   D. .765 inch
   E. None of the above answers is correct.

7. On spur gears, the tooth thickness equals 1.5708/P (the diametral pitch). If the diametral pitch of the gear is 24, what is the thickness of the teeth?
   A. .065"
   B. .377"
   C. .153"
   D. .655"
   E. None of the above answers is correct.

8. The finishing speed for low-carbon steels is 120 surface feet per minute (CS). The diameter of a given workpiece is 3" (D). Using the formula for determining machine speeds, rpm = (4 x CS)/D, what is the rpm?
   A. 10
   B. 160
   C. 1440
   D. Not enough information is given to solve the problem.
   E. None of the above answers is correct.

9. The technician must cut twenty-four plates, each 3" x 6". If the stock is one foot wide and three feet long, how many plates can the technician cut from one plate? Assume no waste or thickness of cut.
   A. 6
   B. 12
   C. 24
   D. 36
   E. None of the above answers is correct.

10. **If the thickness of the saw blade is 1/8", how many bars, each exactly 6" long, can be cut from one three-foot piece of stock?**

A. 3
B. 4
C. 5
D. 6
E. None of the above answers is correct.

MFG-B4
Perform Basic Algebraic Operations
Self-Assessment Answer Key

1. A
2. B
3. C
4. E
5. C
6. C
7. A
8. B
9. C
10. C

MFG-B5

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B5

Subject: **Manufacturing Technology** **Time: 20 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Use Practical Geometry

Objective(s):

Upon completion of this module the student will be able to:

a. Calculate angles;
b. Calculate length of triangle sides;
c. Calculate radius, diameter, circumference, and area of a circle; and,
d. Understand the applications of planar geometry to solid forms.

Instructional Materials:

MASTER Handout (MFG-B5-HO);
MASTER Self-Assessment;
Paper
Pencil
Chalk Board
Overhead Projector
Various Geometric Objects

References:

Applied Electronic Math, with Calculators, Tontsch, John W., Latest Edition

Applied Math, Bajpai, Avi C.; Bond, Rodney M.; adapted by Jerry W. Jones, Latest Edition

Applied Math for Technicians, Moore, Claude S.; Griffin, Bennie L.; Polhamus, Edward C., Jr.; {drawings, George E. Morris.}, Latest Edition

Basic Business Math, Dansby, Robert L., Latest Edition

Basic Electronics Math with a Scientific Calculator, by Noll, Edward M., Latest Edition

Becoming a Mental Math Wizard, Lucas, Jerry, Latest Edition

Building Success in Math, Langbort, Carol R.; Thompson, Virginia H., Latest Edition

Business Math Basics, Swindle, Robert E., Latest Edition

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-B1	"Perform Basic Arithmetic Functions"
MFG-B4	"Perform Basic Algebraic Operations"

Introduction:

Geometry is used to calculate lengths, angles, arcs, areas, and volumes of various shapes and objects. These shapes and objects are the meat and bread of machining; they are machining's sole purpose for existence. The technician takes a workpiece that may not bear any resemblance at all to the finished part, and turns it into that part. A basic understanding of these shapes and how they relate to each other is necessary to the survival of the technician. These shapes and relationships are also geometry.

Presentation Outline:

I. Some Rules of Angles
  A. Angles are usually expressed in degrees, minutes, and seconds
  B. No angle has more than 360°
  C. Angles have three points which determine them
  D. An angle having 90° is a right angle
II. Triangles
  A. Pythagorean Theorem: $a^2 + b^2 = c^2$
  B. All the angles in a triangle will add up to 180°, every day, every time, every triangle
  C. Have three corners. If one of them is 90°, then it is a right triangle.
  D. The absolute size of a triangle cannot be determined by its angles alone. At least one side must be known.
III. Circle
  A. 360°, every day, every time, every circle
  B. Pi (π) 3.1416 and its importance
  C. $2\pi r = d$, where r is the circle's radius and d, its diameter
IV. Rectangles and Parallelograms
  A. Squares and rectangles
    1. Have four 90° corners
    2. Squares are rectangles all of whose sides are equal
  B. Parallelograms
    1. Have four corners not 90°

2. Have (at least) two parallel sides

V. Relating Planar Geometry to Solid Forms

In reality, planar geometry is an abstract way of looking at *parts* of solid things. Look at a piece of 1" CRS—at each end, it is a circle, so all the rules of circles apply to it, but only when looked at from the end. When you look at it from the sides, the rules for lines apply. So, that piece of 1" CRS, which is actually a cylinder, can be looked at as two circles joined by a line. Square workpieces have the same properties. No matter which way you look at them, each face is a rectangle or a parallelogram; and each face is subject to the rules of rectangles and parallelograms. Tapers are unequal circles joined by an incomplete triangle.

Practical Application:

Students will practice working math problems.

Evaluation and/or Verification:

Successful completion of this Technical Module will be based on the student's successful completion of the written evaluation.

Summary:

Review the main lesson points using the handout (MFG-B5-HO) as a guide for discussion and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-B6) dealing with understanding basic trigonometry.

MFG-B5-HO
Use Practical Geometry
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to:

a. Calculate angles;
b. Calculate length of triangle sides;
c. Calculate radius, diameter, circumference, and area of a circle; and,
d. Understand the applications of planar geometry to solid forms.

Module Outline:

I. Some Rules of Angles
    A. Angles are usually expressed in degrees, minutes, and seconds
    B. No angle has more than 360°
    C. Angles have three points which determine them
    D. An angle having 90° is a right angle
II. Triangles
    A. Pythagorean Theorem: $a^2 + b^2 = c^2$
    B. All the angles in a triangle will add up to 180°, every day, every time, every triangle
    C. Have three corners. If one of them is 90°, then it is a right triangle.
    D. The absolute size of a triangle cannot be determined by its angles alone. At least one side must be known.
III. Circle
    A. 360°, every day, every time, every circle
    B. Pi (π) 3.1416 and its importance
    C. $2\pi r = d$, where r is the circle's radius and d, its diameter
IV. Rectangles and Parallelograms
    A. Squares and rectangles
        1. Have four 90° corners
        2. Squares are rectangles all of whose sides are equal
    B. Parallelograms
        1. Have four corners not 90°
        2. Have (at least) two parallel sides
V. Relating Planar Geometry to Solid Forms

In reality, planar geometry is an abstract way of looking at *parts* of solid things. Look at a piece of 1" CRS—at each end, it is a circle, so all the rules of circles apply to it, but only when looked at from the end. When you look at it from the sides, the rules for lines apply. So, that piece of 1" CRS, which is actually a cylinder, can be looked at as two circles joined by a line. Square workpieces have the same properties. No matter which way you look at them, each face is a rectangle or a parallelogram; and each face is subject to the rules of rectangles and parallelograms. Tapers are unequal circles joined by an incomplete triangle.

Name________________________ Date______________________

MFG-B5
Use Practical Geometry
Self-Assessment

Solve the following problems:

1. The technician is told to turn down a three-inch piece of 1" CRS to 3/4". What is the length of the new radius of the CRS?
   A. .750"
   B. .500"
   C. .375"
   D. .125"
   E. None of the above answers is correct.

2. The technician must bore six 1" holes in a plate. The holes must be bored in a eight-inch diameter circle and must be equally spaced. How many degrees apart are the holes?
   A. 30°
   B. 60°
   C. 90°
   D. 120°
   E. None of the above answers is correct.

3. The technician must cut triangular iron plates for a construction project. One angle is 80° and one of the others is 50°. What is the measure of the third angle?
   A. 230°
   B. 165°
   C. 50°
   D. Not enough information is given to solve the problem.
   E. None of the above answers is correct.

4. The technician is given six discs, each 3" in diameter. Each disc must be bored so that it produces an eccentricity of 1/2". How far off center does the technician drill the hole?
   A. 1/8"
   B. 1/4"
   C. 1/2"
   D. $1/4\pi$"
   E. None of the above answers is correct.

5. The technician must cut a set of 1/2" square teeth along the top of a 6' rectangular rod. The top flat and the valley flat are equal and each end of the rod ends in a top flat. How many valley flats must be cut? (Note: There will be scrap.)

A. 36
B. 71
C. 70
D. 102
E. None of the above answers is correct.

MFG-B5
Use Practical Geometry
Self-Assessment Answer Key

1. C

2. B

3. C

4. B

5. B

MFG-B6

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B6

Subject: **Manufacturing Technology** **Time: 4 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Understand Basic Trigonometry

Objective(s):

Upon completion of this unit the student will be able to:
a. Solve for unknown angles;
b. Solve for unknown sides; and,
c. Calculate bolt hole patterns.

Instructional Materials:

Scientific Calculator capable of trigonometric functions
MASTER Handout (MFG-B6-HO)
MASTER Laboratory Aid (MFG-B6-LA)
MASTER Self-Assessment

References:

Machinery's Handbook, Industrial Press, Latest Edition, "Solution of Triangles"
Student's Shop Reference Handbook, Industrial Press, Latest Edition, "Mathematics: Solution of Triangles"

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-B1 "Perform Basic Arithmetic Functions"

Introduction:

Trigonometry for the machinist is actually quite simple. There is nothing to memorize and the calculations are easy. It is important, however, to the operation of several measuring devices and tools.

Presentation Outline:

- I. Solve for Unknown Angles
  - A. Right triangles
    - 1. Sine Law: sin a = side opposite divided by hypotenuse
    - 2. Cosine Law: cos a = side adjacent divided by hypotenuse
    - 3. Tangent Law: tan a = side opposite divided by side adjacent
    - 4. *O*scar *H*as *A* *H*eap *O*f *A*pples is a quick device to remember the above three runes.
      - a. Sine ∠ = *O*pposite/*H*ypoteneuse
      - b. Cosine ∠ = *A*djacent/*H*ypoteuse
      - c. Tangent ∠ = *O*pposite/*A*djacent
  - B. Oblique Triangles
    - 1. Lengths of three sides (A, B, C) all known
      - a. $\text{Cos } a = (B^2 + C^2 - A^2)/2BC$
      - b. $\text{Sin } b = (B \text{ x } \sin a)/A$
      - c. $c = 180^\circ - (a + b)$
    - 2. Two angles (a and b) known
      $c = 180^\circ - (a + b)$
    - 3. Two sides and interior angle (A, c, B) known
      - a. $\text{Tan } a = (A \text{ x } \sin c)/B\text{-}(A \text{ x } \cos c)$
      - b. $b = 180^\circ - (a + c)$
      - c. $C = (A \text{ x } \sin c)/\sin a$
    - 4. Two sides and an opposite angle (a, A, B) known
      - a. $\text{Sin } b = (B \text{ x } \sin a)/A$
      - b. $c = 180^\circ - (a + b)$
      - c. $C = (A \text{ x } \sin c)/\sin a$
- II. Solve for Unknown Sides
  - A. Right triangles, any two sides known, where C is the hypotenuse
    $A^2 + B^2 = C^2$
  - B. One side and two angles (a, b, A) known
    - 1. $c = 180^\circ - (a + b)$
    - 2. $B = (A \text{ x } \sin b)/\sin a$
    - 3. $C = (A \text{ x } \sin c)/\sin a$
  - C. Two sides and the interior angle (A, B, c) known
    $C = \sqrt{[A^2 + B^2 - (2AB \text{ x } \cos c)]}$
  - D. Three angles known
    It is impossible to determine the actual length of any side when only the sizes of the three angles are known. The length of at least one side *must* be known in order to calculate the lengths of the other sides.
- III. Calculate Bolt Hole Patterns
  - A. Discuss the construction of reference triangles to solve bolt-hole patterns
  - B. Discuss circles and their uses in figuring bolt-hole patterns.

Practical Application:

Students will display the ability to correctly lay out bolt hole patterns and to compute angular distances using trigonometry. This module also prepares students for the use of sine bars and sine plates.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-B7) dealing with calculating speeds and feeds for machining.

MFG-B6-HO
Understand Basic Trigonometry
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. **Solve for unknown angles;**
- b. **Solve for unknown sides; and,**
- c. **Calculate bolt hole patterns.**

Module Outline:

- I. Solve for Unknown Angles
  - A. Right triangles
    - 1. Sine Law: sin a = side opposite divided by hypotenuse
    - 2. Cosine Law: cos a = side adjacent divided by hypotenuse
    - 3. Tangent Law: tan a = side opposite divided by side adjacent
    - 4. *O*scar *H*as *A* *H*eap *O*f *A*pples is a quick device to remember the above three runes.
      - a. Sine ∠ = *O*pposite/*H*ypoteneuse
      - b. Cosine ∠ = *A*djacent/*H*ypoteuse
      - c. Tangent ∠ = *O*pposite/*A*djacent
  - B. Oblique Triangles
    - 1. Lengths of three sides (A, B, C) all known
      - a. $\text{Cos } a = (B^2 + C^2 - A^2)/2BC$
      - b. $\text{Sin } b = (B \times \sin a)/A$
      - c. $c = 180° - (a + b)$
    - 2. Two angles (a and b) known

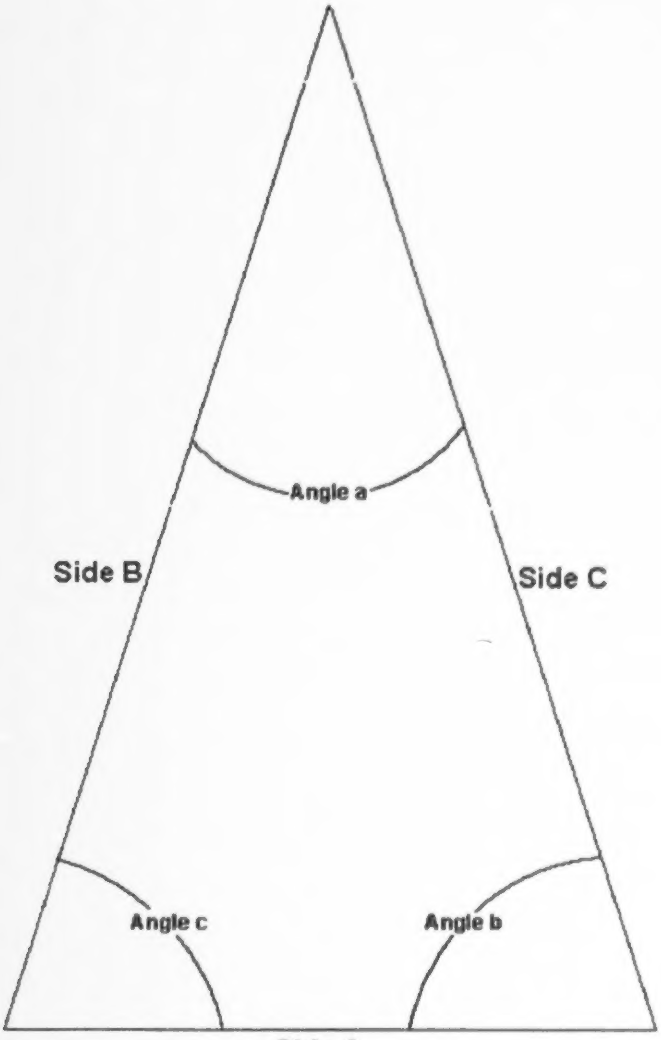
      $c = 180° - (a + b)$
    - 3. Two sides and interior angle (A, c, B) known
      - a. $\text{Tan } a = (A \times \sin c)/B-(A \times \cos c)$
      - b. $b = 180° - (a + c)$
      - c. $C = (A \times \sin c)/\sin a$
    - 4. Two sides and an opposite angle (a, A, B) known
      - a. $\text{Sin } b = (B \times \sin a)/A$
      - b. $c = 180° - (a + b)$
      - c. $C = (A \times \sin c)/\sin a$
- II. Solve for Unknown Sides
  - A. Right triangles, any two sides known, where C is the hypotenuse

    $A^2 + B^2 = C^2$
  - B. One side and two angles (a, b, A) known
    - 1. $c = 180° - (a + b)$
    - 2. $B = (A \times \sin b)/\sin a$

        3. $C = (A \times \sin c)/\sin a$
    C. Two sides and the interior angle (A, B, *c*) known
       $C = \sqrt{[A^2 + B^2 - (2AB \times \cos c)]}$
    D. Three angles known
       It is impossible to determine the actual length of any side when only the sizes of the three angles are known. The length of at least one side *must* be known in order to calculate the lengths of the other sides.

III. Calculate Bolt Hole Patterns
    A. Discuss the construction of reference triangles to solve bolt-hole patterns
    B. Discuss circles and their uses in figuring bolt-hole patterns.

MFG-B6-LA
Understand Basic Trigonometry
Attachment 2: MASTER Laboratory Aid


Angle a
Side B
Side C
Angle c
Angle b
Side A

Basic Triangle - MFG-B6

Name__________________________ Date_______________

MFG-B6
Understand Basic Trigonometry
Self-Assessment

Using the reference triangle on the accompanying page, solve the following triangles from the information given. Show all work.

1. Side A = 9"; Side B = 8"; Side C = 12"; solve for all angles. The triangle is oblique.

2. Side A = 6 cm; Angle *c* = 60°; Side B = 12 cm; solve for Angle *a*..

3. Angle *a* = 35°; Angle *b* = 57° 30'; solve for Angle *c*.

4. Angle *a* = 40°; Side A = 18"; Side B = 12"; solve for Angles *b* & *c*.

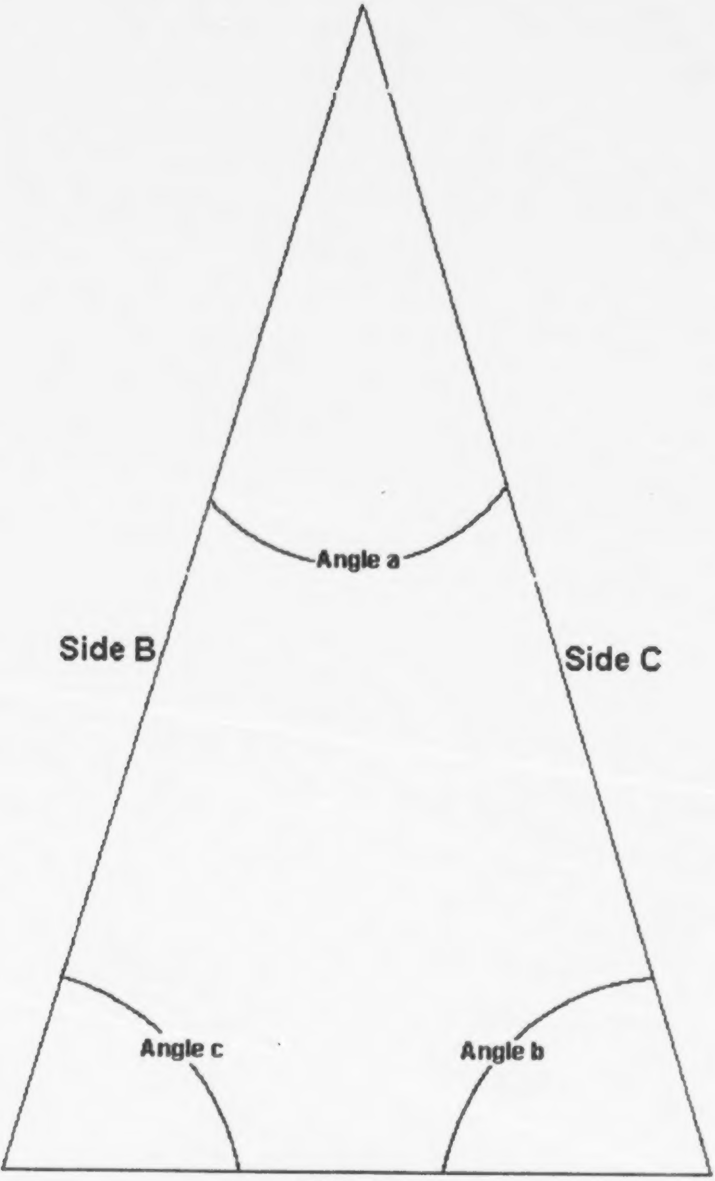
5. Side A = cm; Angle *c* = 90°; Side B = 12 cm; solve for Side C.

6. Angle *a* = 22° 30'; Angle *b* = Angle *a*; Side A = 9"; solve for Sides B & C.

7. Side A = 12 cm; Side B = 12 cm; Angle *c* = 60°; solve for Side C.

8. The triangle is a right triangle. Side A = 3'; Side B = 4'; Side C = 5'; solve for all angles.

9. A right triangle has two 45° angles. Solve for the sides, in inches.

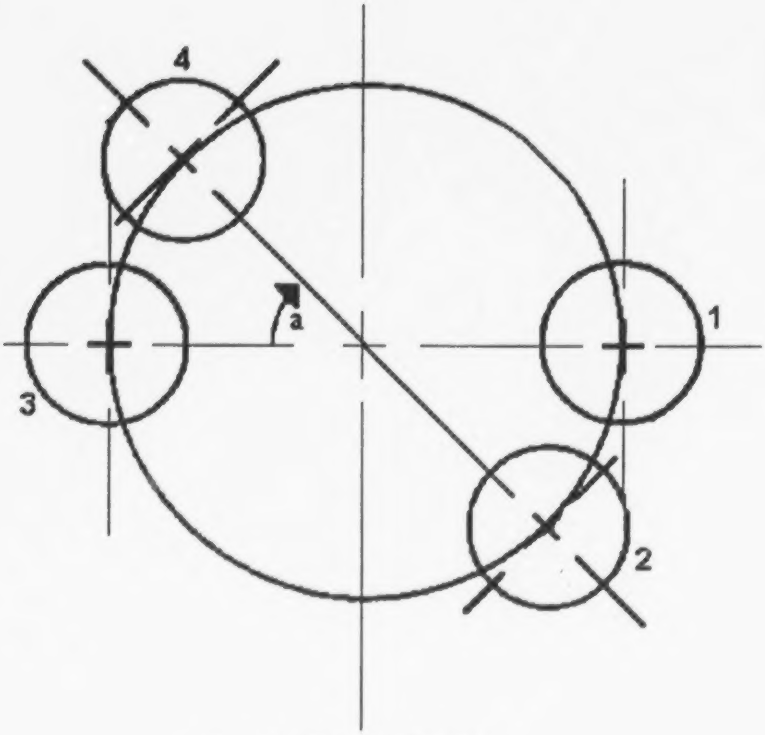

Angle a
Side B
Side C
Angle c
Angle b
Side A

Basic Triangle - MFG-B6

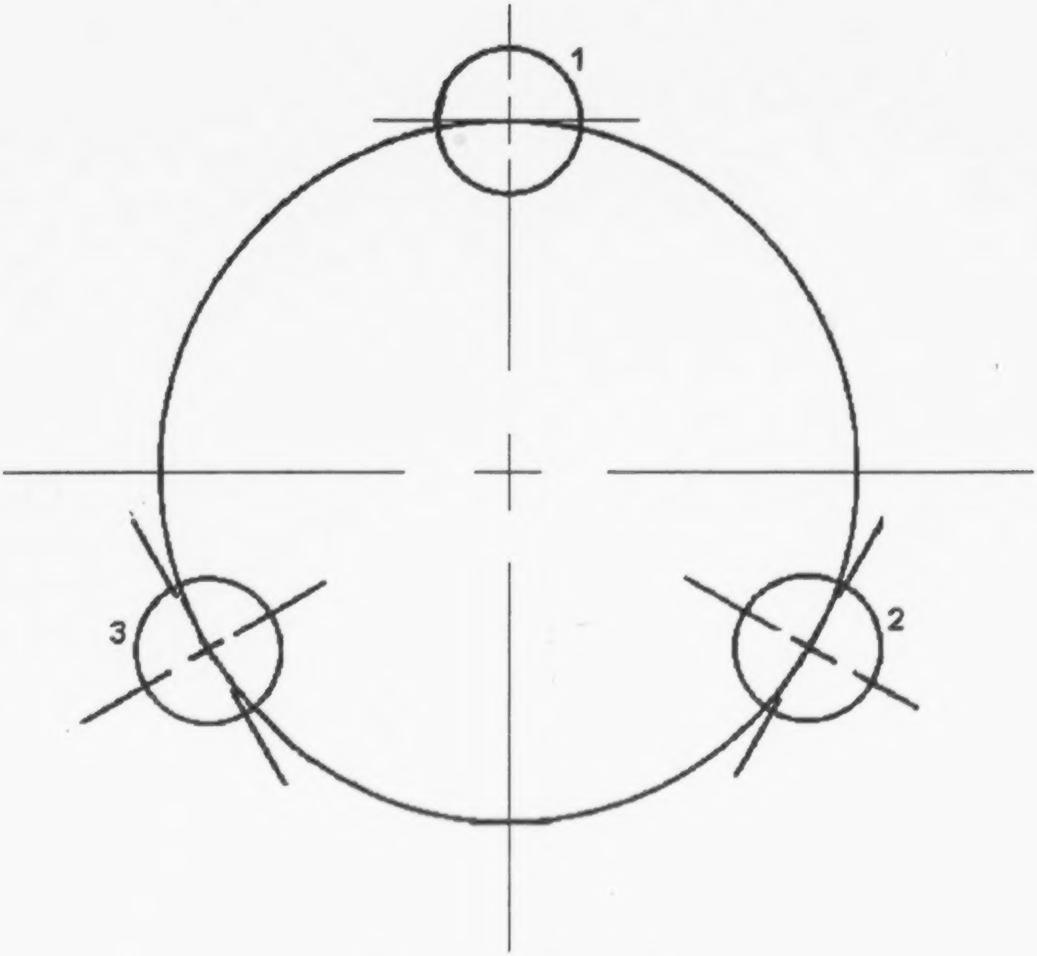
Using the two bolt-hole patterns shown in the illustrations on the accompanying page, solve the following questions. Remember that the answers should be in the form of *x,y*.

10. Four holes are spaced around a 2" semi-circle. If Hole One is at 1,0; where are the other three holes?

11. Three equally-spaced holes around a 6" diameter reference circle. If Hole One is at 0,3; where are the other two holes?



Question No. 10 - MFG-B6



Question No. 11 - MFG-B6

MFG-B6
Understand Basic Trigonometry
Self-Assessment Answer Key

1. a = 48.59° b = 41.81° c = 89.6°
2. a = 86.11°
3. c = 87° 30'
4. b = 25.37° c =114.63°
5. Side C = 13.41 cm
6. Side B = 9" Side C = 16.63"
7. Side C = 12 cm
8. Angle a = 36.87° Angle b = 53.13° Angle c = 90°
9. The problem is impossible to solve.
10. Hole 1: 1,0 Hole 2: 0.7071, -0.7071
    Hole 3: -1,0 Hole 4: -0.7071, 0.7071
11. Hole 1: 0, 3 Hole 2: 0.866, -0.500 Hole 3: -0.500, -0.866

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B7

Subject: **Manufacturing Technology** **Time: 6 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Calculate Speeds and Feeds for Machining

Objective(s):

Upon completion of this unit the student will be able to:

a. Calculate RPM for various metals and various tools; and,
b. Calculate feed for various metals, tools, and depths of cut.

Instructional Materials:

MASTER Handout (MFG-B7-HO)
MASTER Laboratory Aid (MFG-B7-LA)
MASTER Self-Assessments (two)

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, Section F: Preparation for Machining Operations, Unit 2: Speeds and Feeds for Machine Tools

Machinery's Handbook, Industrial Press, Latest Edition, "Cutting Feeds and Speeds"

NTMA Modules:

MA-I-22	"Milling Machines: Speeds & Feeds/Problems"
MA-I-36	"Engine Lathe: Selecting Speeds & Feeds"
MA-I-51	"Pocket Calculators: Speeds & Feeds"

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-B1 "Perform Basic Arithmetic Functions"

Introduction:

The most important decisions which the machinist must make when machining a workpiece are: (1) What are the optimum speeds for each machine operation? If the machine is run too fast or too slow, machining time and part quality may be greatly sacrificed. (2) What are the optimum feeds for each machine operation? If the tool is

fed into the work too fast or too slow production rates may be reduced significantly. (3) What depths of cuts will remove excess material and bring the part to the desired size most quickly? If too shallow of cuts are made, much time will be wasted and desired surface finish will not be achieved. One of the characteristics of an expert machinist is the ability choose the most efficient speeds, feeds and depths of cuts for the parts he is called on to machine.

Presentation Outline:

I. Calculate RPM for Various Metals and Various Tools
  A. Cutting speed (CS) defined - the surface feet per minute (sf/min) or meters per minute (m/min) at which the metal may be machined efficiently. When work is machined on a lathe, it must be turned at a specific number of revolutions per minute (rpm), *depending on its diameter*, to achieve the proper cutting speed. When work is machined on a milling machine, the cutter must be revolved at a specified number of rpm's, *depending on its diameter*, to achieve the proper cutting speed.
  B. Factors affecting proper cutting speed
    1. Type of work material (aluminum, bronze, steel, etc.)
    2. Type of cutter (high-speed, carbide etc.)
    3. Diameter of the cutter
    4. Surface finish required
    5. Depth of cut
    6. Rigidity of the machine and the work setup
  C. Sources for determining recommended cutting speeds
    1. ***Machinery's Handbook***
    2. The text
    3. Cutting tool and insert manufacturers
    4. Experience of the machinist
  D. Determining correct RPM
    1. Inch RPM calculations ...
       RPM = (CS x 4) ÷ Diam.
    2. Metric RPM calculations ...
       RPM = (CS (m) x 1000) ÷ (π x Diam. (mm))
    3. See charts 7.1 and 7.2 in this module
  E. Problems related to using the wrong cutting speed
    1. Cutting speed too slow
      a. Time will be lost for machining (low production rates)
      b. Broken tool bits
    2. Cutting speed too fast
      a. Cutting tool edge breaks down
      b. Loss in production time due to reconditioning/replacing the tool

- F. Student practice using the "Determining Correct RPM" exercise and recommended speed charts found in this module

II. Calculate Feed for Various Metals, Tools, and Depths of Cut

- A. Feed defined - feed may be defined as the distance the tool advances into the work for every revolution.
    1. When work is machined on a lathe, feed is the distance, in inches (or millimeters), the cutting tool advances along the length of the work for every revolution of the spindle. Lathe feeds are generally expressed as inches (or millimeters) per revolution (ipr).
    2. When work is machined on a milling machine, feed is the distance, in inches (or millimeters) per minute, that the work moves into the cutter. Milling feeds are generally expressed as inches (or millimeters) per minute (ipm).
- B. Factors affecting proper feed
    1. Depth and width of cut
    2. Design or type of cutter
    3. Sharpness of the cutter
    4. Workpiece material
    5. Strength and uniformity of the workpiece
    6. The of finish and accuracy required
    7. Power and rigidity of the machine
- C. Sources for determining cutting optimal cutting speeds
    1. *Machinery's Handbook*
    2. The text
    3. Cutting tool and insert manufacturers
    4. Experience of the machinist
- D. Methods for determining correct feed
    1. Depth of cut - rule of thumb
        - a. When possible, only two cuts should be used to bring a part to size: a roughing cut and a finishing cut.
        - b. Since the purpose of a roughing cut is to remove excess material quickly and surface finish is not too important, a heavy depth of cut with a course feed should be used.
        - c. The finishing cut is used to bring the diameter to size and produce a good surface finish and therefore a lighter depth of cut with a fine feed should be used.
        - d. If much material must be removed, the roughing cuts should be as deep as possible to reduce the size of the part to within .020" to .030" of the size required.
    2. Lathe feed guidelines
        1. Roughing - .010" to .030" (.25 mm to .75 mm) per revolution
        2. Finishing - .003" to .010" (.07 mm to .25 mm) per revolution

3. See chart 7.4 in this module
3. Mill feed guidelines
a. Inch feed calculation ...
Feed (ipm) = N x chip per tooth x RPM
where N = number of teeth on the cut
b. Metric feed calculation ... feed (mm/min) = same as above
c. See charts 7.4 and 7.5 in this module
E. Problems related to using the wrong feed
1. Feed speed too slow
a. Time will be lost for machining (low production rates)
b. Broken tool bits
2. Feed too fast
a. Cutting tool edge breaks down
b. Loss in production time due to reconditioning/replacing the tool
F. Student practice using the "Calculate Speeds and Feeds for Machining" exercise and the recommended feed charts found in this module

Practical Application:

Students should successfully complete the two Self-Assessments found in this lesson.

Evaluation and/or Verification:

Students should make 90% or above on the two Self-Assessments found in this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-B8) dealing with coordinate systems.

MFG-B7-HO
Calculate Speeds and Feeds for Machining
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Calculate RPM for various metals and various tools; and,
b. Calculate feed for various metals, tools, and depths of cut.

Module Outline:

I. Calculate RPM for Various Metals and Various Tools
   - A. Cutting speed (CS) defined - the surface feet per minute (sf/min) or meters per minute (m/min) at which the metal may be machined efficiently. When work is machined on a lathe, it must be turned at a specific number of revolutions per minute (rpm), *depending on its diameter*, to achieve the proper cutting speed. When work is machined on a milling machine, the cutter must be revolved at a specified number of rpm's, *depending on its diameter*, to achieve the proper cutting speed.
   - B. Factors affecting proper cutting speed
     - 1. Type of work material (aluminum, bronze, steel, etc.)
     - 2. Type of cutter (high-speed, carbide etc.)
     - 3. Diameter of the cutter
     - 4. Surface finish required
     - 5. Depth of cut
     - 6. Rigidity of the machine and the work setup
   - C. Sources for determining recommended cutting speeds
     - 1. ***Machinery's Handbook***
     - 2. The text
     - 3. Cutting tool and insert manufacturers
     - 4. Experience of the machinist
   - D. Determining correct RPM
     - 1. Inch RPM calculations ...
       $RPM = (CS \times 4) \div Diam.$
     - 2. Metric RPM calculations ...
       $RPM = (CS\ (m) \times 1000) \div (\pi \times Diam.\ (mm))$
     - 3. See charts 7.1 and 7.2 in this module
   - E. Problems related to using the wrong cutting speed
     - 1. Cutting speed too slow
       - a. Time will be lost for machining (low production rates)
       - b. Broken tool bits
     - 2. Cutting speed too fast

a. Cutting tool edge breaks down
b. Loss in production time due to reconditioning/replacing the tool
F. Student practice using the "Determining Correct RPM" exercise and recommended speed charts found in this module
II. Calculate Feed for Various Metals, Tools, and Depths of Cut
A. Feed defined - feed may be defined as the distance the tool advances into the work for every revolution.
1. When work is machined on a lathe, feed is the distance, in inches (or millimeters), the cutting tool advances along the length of the work for every revolution of the spindle. Lathe feeds are generally expressed as inches (or millimeters) per revolution (ipr).
2. When work is machined on a milling machine, feed is the distance, in inches (or millimeters) per minute, that the work moves into the cutter. Milling feeds are generally expressed as inches (or millimeters) per minute (ipm).
B. Factors affecting proper feed
1. Depth and width of cut
2. Design or type of cutter
3. Sharpness of the cutter
4. Workpiece material
5. Strength and uniformity of the workpiece
6. The of finish and accuracy required
7. Power and rigidity of the machine
C. Sources for determining cutting optimal cutting speeds
1. *Machinery's Handbook*
2. The text
3. Cutting tool and insert manufacturers
4. Experience of the machinist
D. Methods for determining correct feed
1. Depth of cut - rule of thumb
a. When possible, only two cuts should be used to bring a part to size: a roughing cut and a finishing cut.
b. Since the purpose of a roughing cut is to remove excess material quickly and surface finish is not too important, a heavy depth of cut with a course feed should be used.
c. The finishing cut is used to bring the diameter to size and produce a good surface finish and therefore a lighter depth of cut with a fine feed should be used.
d. If much material must be removed, the roughing cuts should be as deep as possible to reduce the size of the part to within .020" to .030" of the size required.
2. Lathe feed guidelines

        1. Roughing - .010" to .030" (.25 mm to .75 mm) per revolution
        2. Finishing - .003" to .010" (.07 mm to .25 mm) per revolution
        3. See chart 7.4 in this module
    3. Mill feed guidelines
        a. Inch feed calculation ...

           Feed (ipm) = N x chip per tooth x RPM

           where N = number of teeth on the cut
        b. Metric feed calculation ... feed (mm/min) = same as above
        c. See charts 7.4 and 7.5 in this module

E. Problems related to using the wrong feed
    1. Feed speed too slow
        a. Time will be lost for machining (low production rates)
        b. Broken tool bits
    2. Feed too fast
        a. Cutting tool edge breaks down
        b. Loss in production time due to reconditioning/replacing the tool

F. Student practice using the "Calculate Speeds and Feeds for Machining" exercise and the recommended feed charts found in this module

MFG-B7-LA
Calculate Speeds and Feeds for Machining
Attachment 2: MASTER Laboratory Aid

TABLE 7.1

Lathe Cutting Speeds in Feet & Meters Per Minute Using a High-Speed Toolbit

Material	Turning & Boring				Threading	
	Rough Cut		Finish Cut			
	ft/min	m/min	ft/min	m/min	ft/min	m/min
Machine Steel	90	27	100	30	35	11
Tool Steel	70	21	90	27	30	9
Cast Iron	60	18	80	24	25	8
Bronze	90	27	100	30	25	8
Aluminum	200	61	300	93	60	18

TABLE 7.2

Milling Machine Cutting Speeds

Material	High-Speed Steel Cutter		Carbide Cutter	
	ft/min	m/min	ft/min	m/min
Machine Steel	70-100	21-30	150-250	45-75
Tool Steel	60-70	18-20	125-200	40-60
Cast Iron	50-80	15-25	125-200	40-60
Bronze	65-120	20-35	200-400	60-120
Aluminum	500-1000	150-300	1000-2000	150-300

TABLE 7.3

Feeds for Various Materials (Using a High-Speed Cutting Tool)

Materials	Rough Cuts		Finish Cuts	
	Inches	Millimeters	Inches	Millimeters
Machine Steel	0.010-0.020	0.25-0.50	0.003-0.010	0.07-0.25
Tool Steel	0.010-0.020	0.25-0.50	0.003-0.010	0.07-0.25
Cast Iron	0.015-0.025	0.40-0.65	0.005-0.012	0.13-0.30
Bronze	0.015-0.025	0.40-0.65	0.003-0.010	0.07-0.25
Aluminum	0.015-0.030	0.40-0.75	0.005-0.010	0.13-0.25

TABLE 7.4

Recommended Feed per Tooth (High-Speed Steel Cutters)

Material	Face Mills		Helical Mills		Slotting & Side Mills		End Mills		Form-Relieved Cutters	
	In.	mm	In.	mm	In.	mm	In.	mm	In.	mm
Aluminum	0.022	0.55	0.018	0.45	0.013	0.33	0.011	0.28	0.007	0.18
Brass & Bronze (medium)	0.014	0.35	0.011	0.28	0.008	0.20	0.007	0.18	0.004	0.10
Cast Iron (medium)	0.013	0.33	0.010	0.25	0.007	0.18	0.007	0.18	0.004	0.10
Machine Steel	0.012	0.30	0.010	0.25	0.007	0.18	0.006	0.15	0.004	0.10
Tool Steel (medium)	0.010	0.25	0.008	0.20	0.006	0.15	0.005	0.13	0.003	0.08
Stainless Steel	0.006	0.15	0.005	0.13	0.004	0.10	0.003	0.08	0.002	0.05

TABLE 7.5

Recommended Feed per Tooth (Cemented-Carbide-Tipped Cutters)

Material	Face Mills		Helical Mills		Slotting & Side Mills		End Mills		Form-Relieved Cutters	
	In.	mm	In.	mm	In.	mm	In.	mm	In.	mm
Aluminum	0.020	0.50	0.016	0.40	0.012	0.30	0.010	0.25	0.006	0.15
Brass & Bronze (medium)	0.012	0.30	0.010	0.25	0.007	0.18	0.006	0.15	0.004	0.10
Cast Iron (medium)	0.016	0.40	0.013	0.33	0.010	0.25	0.008	0.20	0.005	0.13
Machine Steel	0.016	0.40	0.013	0.33	0.009	0.23	0.008	0.20	0.005	0.13
Tool Steel (medium)	0.014	0.35	0.011	0.28	0.008	0.20	0.007	0.18	0.004	0.10
Stainless Steel	0.010	0.25	0.008	0.20	0.006	0.15	0.005	0.13	0.003	0.08

Name______________________________ Date_________________

MFG-B7
Calculate Speeds and Feeds for Machining
Self-Assessment 1

Using Tables 7.1 and 7.2 on the following pages, calculate the correct roughing and finishing speeds for the following materials. Write your answer in the space provided. (Show all work.)

1. Aluminum - 2.0" diameter (Lathe)

   Answer (roughing) = _______ Answer (finishing) = _______

2. Machine steel - .75" (high speed) end mill

   Answer (roughing) = _______ Answer (finishing) = _______

3. Tool steel - .5" (carbide) end mill

   Answer (roughing) = _______ Answer (finishing) = _______

4. Cast iron - 5.0" diameter (Lathe)

   Answer (roughing) = _______ Answer (finishing) = _______

5. Bronze - 1.125" diameter (Lathe)

Answer (roughing) = ______ Answer (finishing) = ______

6. Aluminum - 18 mm (high speed) end mill

Answer (roughing) = ______ Answer (finishing) = ______

7. Bronze - 25 mm diameter (Lathe)

Answer (roughing) = ______ Answer (finishing) = ______

8. Tool steel - 40 mm diameter (Lathe)

Answer (roughing) = ______ Answer (finishing) = ______

9. Machine steel - 12 mm (carbide) end mill

Answer (roughing) = ______ Answer (finishing) = ______

10. Cast iron - 6 mm (high speed) end mill

Answer (roughing) = ______ Answer (finishing) = ______

TABLES FOR MFG-B7
Calculating Speeds and Feeds for Machining

TABLE 7.1

Lathe Cutting Speeds in Feet & Meters Per Minute Using a High-Speed Toolbit						
Material	**Turning & Boring**				**Threading**	
	Rough Cut		**Finish Cut**			
	ft/min	**m/min**	**ft/min**	**m/min**	**ft/min**	**m/min**
Machine Steel	90	27	100	30	35	11
Tool Steel	70	21	90	27	30	9
Cast Iron	60	18	80	24	25	8
Bronze	90	27	100	30	25	8
Aluminum	200	61	300	93	60	18

TABLE 7.2

Milling Machine Cutting Speeds				
Material	High-Speed Steel Cutter		Carbide Cutter	
	ft/min	**m/min**	**ft/min**	**m/min**
Machine Steel	70-100	21-30	150-250	45-75
Tool Steel	60-70	18-20	125-200	40-60
Cast Iron	50-80	15-25	125-200	40-60
Bronze	65-120	20-35	200-400	60-120
Aluminum	500-1000	150-300	1000-2000	150-300

MFG-B7

Calculating Speeds and Feeds for Machining

Self-Assessment 1 Answer Key

1. Roughing: 400 RPM
   Finishing: 640 RPM

2. Roughing: 373-1/3 RPM
   Finishing: 533-1/3 RPM

3. Roughing: 480 RPM
   Finishing: 560 RPM

4. Roughing: 48 RPM
   Finishing: 52 RPM

5. Roughing: 320 RPM
   Finishing: 355.556 RPM

6. Roughing: 2652.6 RPM
   Finishing: 5305 RPM

7. Roughing: 343.8 RPM
   Finishing: 382 RPM

8. Roughing: 167 RPM
   Finishing: 215 RPM

9. Roughing: 557 RPM
   Finishing: 37.7 RPM

10. Roughing: 796 RPM
    Finishing: 1326.3 RPM

Name_________________________ Date______________

MFG-B7
Calculating Speeds and Feeds for Machining
Self-Assessment 2

Using Tables 7.3, 7.4, and 7.5 on the following pages, determine the correct roughing and finishing feeds for the following materials. Write your answer in the space provided. (Show all work.)

1. Aluminum (inch) (Lathe)

   Answer (roughing) = _______ Answer (finishing) = _______

2. Cast iron (inch) (Lathe)

   Answer (roughing) = _______ Answer (finishing) = _______

3. Tool steel (metric) (Lathe)

   Answer (roughing) = _______ Answer (finishing) = _______

4. Machine steel - (.5" diameter, 4 flute, high speed endmill)

Answer (roughing) = _______ Answer (finishing) = _______

5. Tool steel - (4.0" diameter, 6 tooth, insertable carbide face mill)

Answer (roughing) = _______ Answer (finishing) = _______

6. Aluminum - (12 mm diameter, 2 flute, carbide end mill)

Answer (roughing) = _______ Answer (finishing) = _______

TABLES FOR MFG-B7
Calculating Speeds and Feeds for Machining

TABLE 7.3

Feeds for Various Materials (Using a High-Speed Cutting Tool)

Materials	Rough Cuts		Finish Cuts	
	Inches	Millimeters	Inches	Millimeters
Machine Steel	0.010-0.020	0.25-0.50	0.003-0.010	0.07-0.25
Tool Steel	0.010-0.020	0.25-0.50	0.003-0.010	0.07-0.25
Cast Iron	0.015-0.025	0.40-0.65	0.005-0.012	0.13-0.30
Bronze	0.015-0.025	0.40-0.65	0.003-0.010	0.07-0.25
Aluminum	0.015-0.030	0.40-0.75	0.005-0.010	0.13-0.25

TABLE 7.4

Recommended Feed per Tooth (High-Speed Steel Cutters)

Material	Face Mills		Helical Mills		Slotting & Side Mills		End Mills		Form-Relieved Cutters	
	In.	mm	In.	mm	In.	mm	In.	mm	In.	mm
Aluminum	0.022	0.55	0.018	0.45	0.013	0.33	0.011	0.28	0.007	0.18
Brass & Bronze (medium)	0.014	0.35	0.011	0.28	0.008	0.20	0.007	0.18	0.004	0.10
Cast Iron (medium)	0.013	0.33	0.010	0.25	0.007	0.18	0.007	0.18	0.004	0.10
Machine Steel	0.012	0.30	0.010	0.25	0.007	0.18	0.006	0.15	0.004	0.10
Tool Steel (medium)	0.010	0.25	0.008	0.20	0.006	0.15	0.005	0.13	0.003	0.08
Stainless Steel	0.006	0.15	0.005	0.13	0.004	0.10	0.003	0.08	0.002	0.05

TABLE 7.5

Recommended Feed per Tooth (Cemented-Carbide-Tipped Cutters)

Material	Face Mills		Helical Mills		Slotting & Side Mills		End Mills		Form-Relieved Cutters	
	In.	mm	In.	mm	In.	mm	In.	mm	In.	mm
Aluminum	0.020	0.50	0.016	0.40	0.012	0.30	0.010	0.25	0.006	0.15
Brass & Bronze (medium)	0.012	0.30	0.010	0.25	0.007	0.18	0.006	0.15	0.004	0.10
Cast Iron (medium)	0.016	0.40	0.013	0.33	0.010	0.25	0.008	0.20	0.005	0.13
Machine Steel	0.016	0.40	0.013	0.33	0.009	0.23	0.008	0.20	0.005	0.13
Tool Steel (medium)	0.014	0.35	0.011	0.28	0.008	0.20	0.007	0.18	0.004	0.10
Stainless Steel	0.010	0.25	0.008	0.20	0.006	0.15	0.005	0.13	0.003	0.08

MFG-B7

Calculating Speeds and Feeds for Machining

Self-Assessment 2 Answer Key

1. Roughing: .030 ipr
   Finishing: .005 ipr

2. Roughing: .025 ipr
   Finishing: .005 ipr

3. Roughing: .25 mpr
   Finishing: .25 mpr

4. Roughing: 17.92 ipm
   Finishing: 1.6 ipm

5. Roughing: 5.04 ipm
   Finishing: 5.88 ipm

6. Roughing: 1989.44 ipm
   Finishing: 3978.89 ipm

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B8

Subject: **Manufacturing Technology** **Time: 6 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Use Coordinate Systems

Objective(s):

Upon completion of this unit the student will be able to:
a. Identify points using the Cartesian coordinate system;
b. Identify points using the absolute dimensioning system;
c. Identify points using the incremental dimensioning system; and,
d. Identify points using the polar coordinate system.

Instructional Materials:

Scientific calculator
MASTER Handout (MFG-B8-HO)
MASTER Self-Assessment

References:

Student's Shop Reference Handbook, Industrial Press, Latest Edition, "Mathematics"

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-B1 "Perform Basic Arithmetic Functions"

Introduction:

Many operations which the machinist must perform require the location of holes or other machining locations from a datum or origin point. Many drawings are dimensioned such that part features must be located in reference to another point or part feature. Many of today's machine tools have been fitted with digital read-out equipment which allow the machinist to quickly set and move to the required machining locations. Virtually all of the CNC machines in use today require that the machinist be able to locate and program machining locations using the Cartesian coordinate or the polar coordinate systems. It is, therefore, imperative that the machinist understand and be able to use these coordinate systems.

Presentation Outline:

- I. Identify Points Using the Cartesian Coordinate System
  - A. Describe the Cartesian (rectangular) coordinate system - the basis for all machine movement
    - 1. Define *axis* - any direction of movement on a machine tool. The spindle is always defined as the Z axis on 3 axis systems.
    - 2. Discuss the plus and minus aspects of an axis
    - 3. Discuss the quadrants I, II, III, and IV. Note that the signs for the X- and Y-axes change for the different quadrants.
    - 4. Discuss the concept of three dimensional locations
    - 5. Discuss how points are described in both 2- and 3-axis systems
    - 6. Describe how a part fits into the axis system
- II. Identify Points Using the Polar Coordinate System
  - A. Describe the *polar coordinate system* - a system by which all points are located around a known location (or pole).
    - 1. Points are usually identified by a known distance from the pole and a given angle from the horizontal (3:00 o'clock position equals zero degrees)
    - 2. Positive angles are measured from angle zero in a counterclockwise direction
    - 3. Negative angles are measured from angle zero in a clockwise direction
  - B. Student practice
- III. Locate Points Using the Absolute Dimensioning System
  - A. Define *absolute positioning*- in absolute positioning, all machine locations are taken from one fixed zero (origin) point. This origin point does not change.
  - B. This corresponds to the datum dimensioning method used by drafters. In datum dimensioning, all dimensions on a drawing are placed in reference to one fixed zero point.
  - C. Student practice
- IV. Locate Points Using the Incremental Dimensioning System
  - A. Define *incremental positioning*- in incremental positioning, the X0/Y0 moves with each position change. The current position, in fact, becomes the X0/Y0 for the next positioning move.
  - B. This corresponds to the delta dimensioning method used by drafters. In delta dimensioning, all dimensions on a drawing are "chain-linked." Each location is dimensioned from the previous one.
  - C. Student practice

Practical Application:

Students will be able to calculate boring and cutting patterns for those machines which use datum-point controls.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-B9) dealing with the sine bar and the calculations associated with its use.

MFG-B8-HO
Use Coordinate Systems
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify points using the Cartesian coordinate system;
b. Identify points using the absolute dimensioning system;
c. Identify points using the incremental dimensioning system; and,
d. Identify points using the polar coordinate system.

Module Outline:

I. Identify Points Using the Cartesian Coordinate System
  - A. Describe the Cartesian (rectangular) coordinate system - the basis for all machine movement
    - 1. Define *axis* - any direction of movement on a machine tool. The spindle is always defined as the Z axis on 3 axis systems.
    - 2. Discuss the plus and minus aspects of an axis
    - 3. Discuss the quadrants I, II, III, and IV. Note that the signs for the X- and Y-axes change for the different quadrants.
    - 4. Discuss the concept of three dimensional locations
    - 5. Discuss how points are described in both 2- and 3-axis systems
    - 6. Describe how a part fits into the axis system

II. Identify Points Using the Polar Coordinate System
  - A. Describe the *polar coordinate system* - a system by which all points are located around a known location (or pole).
    - 1. Points are usually identified by a known distance from the pole and a given angle from the horizontal (3:00 o'clock position equals zero degrees)
    - 2. Positive angles are measured from angle zero in a counterclockwise direction
    - 3. Negative angles are measured from angle zero in a clockwise direction
  - B. Student practice

III. Locate Points Using the Absolute Dimensioning System
  - A. Define *absolute positioning*- in absolute positioning, all machine locations are taken from one fixed zero (origin) point. This origin point does not change.
  - B. This corresponds to the datum dimensioning method used by drafters. In datum dimensioning, all dimensions on a drawing are placed in reference to one fixed zero point.
  - C. Student practice

IV. Locate Points Using the Incremental Dimensioning System
   A. Define *incremental positioning-* in incremental positioning, the X0/Y0 moves with each position change. The current position, in fact, becomes the X0/Y0 for the next positioning move.
   B. This corresponds to the delta dimensioning method used by drafters. In delta dimensioning, all dimensions on a drawing are "chain-linked." Each location is dimensioned from the previous one.
   C. Student practice

Name____________________________ Date________________

MFG-B8
Use Coordinate Systems
Self-Assessment

Circle the letter preceding the correct answer.

1. Using the Cartesian plane shown (Diagram 1), what can be said of point 1, regardless of the values of the actual coordinates?
   - A. X is positive and Y is positive.
   - B. X is positive and Y is negative.
   - C. X is negative and Y is positive.
   - D. X is negative and Y is negative.
   - E. None of the above answers is correct.

2. Using Diagram 1, what can be said of point 2, regardless of the actual values of the coordinates?
   - A. X is positive and Y is positive.
   - B. X is positive and Y is negative.
   - C. X is negative and Y is positive.
   - D. X is negative and Y is negative.
   - E. None of the above answers is correct.

3. Which of the following statements is **not** true?
   - A. In absolute dimensioning, all machine locations are taken from a point called the *origin* or *zero point*.
   - B. The origin point is fixed.
   - C. Absolute dimensioning corresponds the drafting method known as *datum dimensioning*.
   - D. In datum dimensioning, all dimensions are determined from a single, fixed point.
   - E. All of the above statements are true.

4. Incremental positioning:
   - A. Corresponds to the drafting method known as *delta dimensioning*.
   - B. Moves the X0/Y0 point after each operation.
   - C. Has "chain-linked" dimensions on the blueprints.
   - D. All of the above answers are applicable to the question.
   - E. None of the above answers is correct.

5. In a three-axis system, the spindle always corresponds to the:
   A. X-axis.
   B. Y-axis.
   C. Z-axis.
   D. The correspondence of the spindle is not standard.
   E. None of the above answers is correct.

6. In the *polar coordinate* system, points are identified by a known distance from the pole and a known ___ from the horizon.
   A. Angle
   B. 3:00 o'clock position
   C. Horizon
   D. Pole
   E. None of the above answers is correct.

For questions 7 through 9, all holes are 3/8 inch diameter and the workpiece setup point corresponds to a point of 6,4 from the table origin.

7. Using Diagram 2 and the absolute dimensioning system, dimension program the part. Show all work. All measurements are in inches.

Hole	X	Y
A		
B		
C		

8. Using Diagram 2 and the incremental dimensioning system, dimension program the part. Show all work. All measurements are in inches.

Hole	X	Y
A		
B		
C		

9. **Using Diagram 3 and the absolute dimensioning system, dimension program the part. Show all work; all linear measurements are in inches.**

Hole	X	Y
A		
B		
C		
D		
E		

10. **Using Diagram 3 and the incremental dimensioning system, dimension program the part. Show all work; all linear measurements are in inches.**

Hole	X	Y
A		
B		
C		
D		
E		

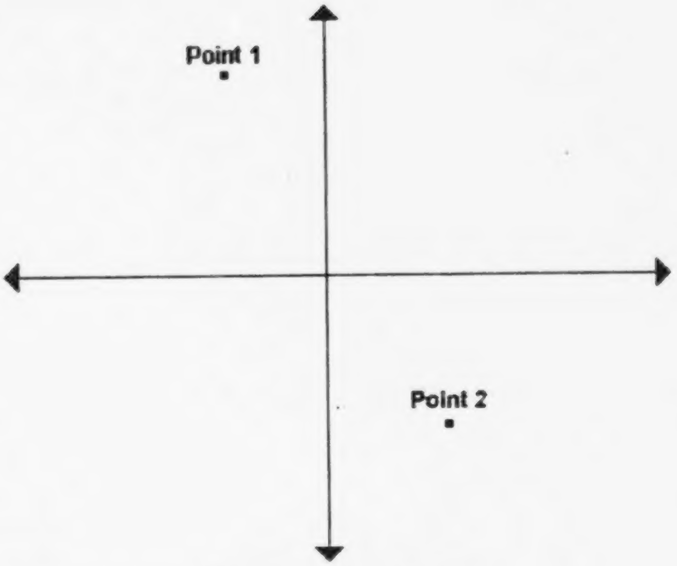

Point 1
Point 2

Diagram 1, MAC-B8

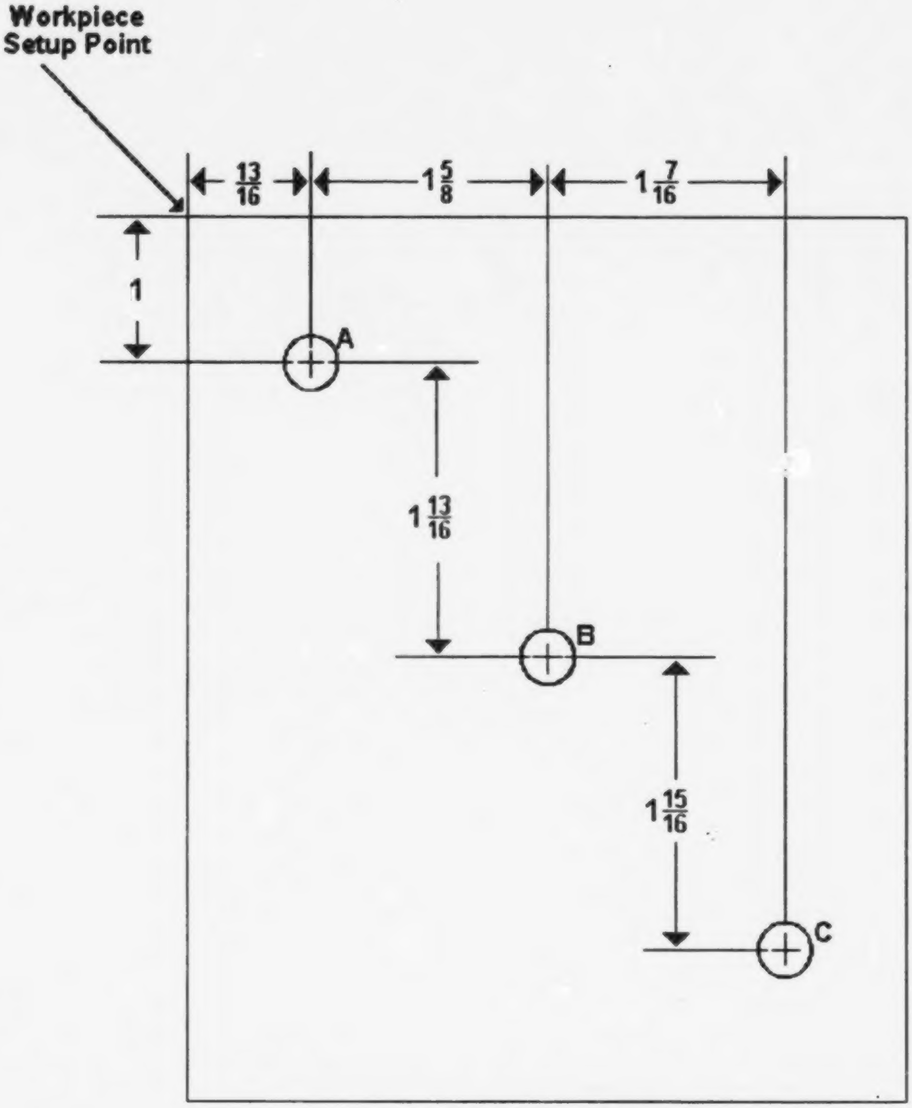

Workpiece
Setup Point
13/16
1 5/8
1 7/16
1
A
1 13/16
B
1 15/16
C

Diagram 2, MAC-B8

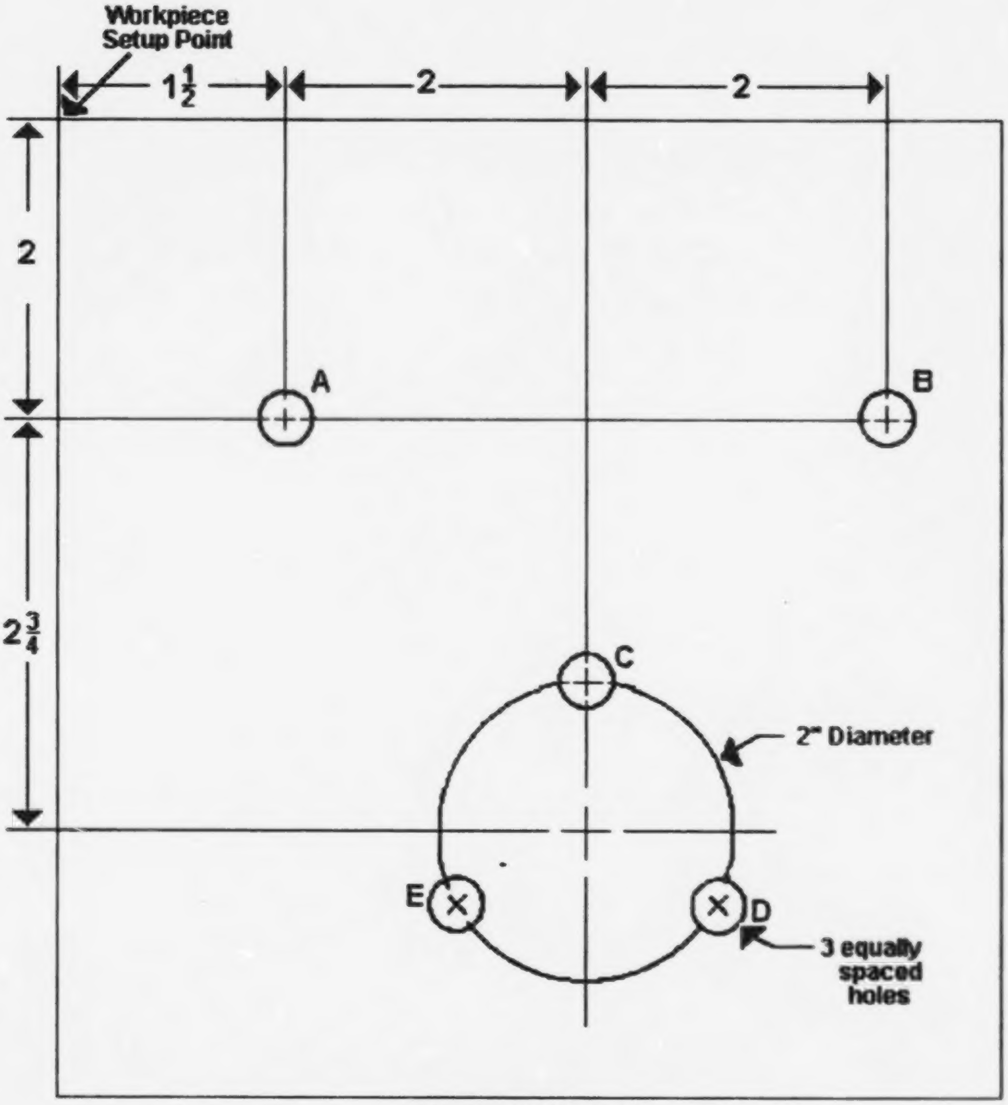

Workpiece Setup Point
1 1/2
2
2
2
2 3/4
A
B
C
2" Diameter
E
D
3 equally spaced holes

Diagram 3, MAC-B8

MFG-B8
Use Coordinate Systems
Self-Assessment Answer Key

1. C

2. D

3. E

4. D

5. C

6. A

7.

Hole	X	Y
A	6 13/16	3
B	8 7/16	1 3/16
C	9 7/8	-3/4

8.

Hole	X	Y
A	6 13/16	3
B	1 5/8	-1 13/16
C	1 7/16	-1 15/16

9.

Hole	X	Y
A	7 ½	2
B	11 ½	2
C	9 ½	1/4
D	10 23/64	-1 1/4
E	8 37/64	-1 1/4

10.

Hole	X	Y
A	7 ½	2
B	4	0
C	-2	-1 3/4
D	55/64	-1 ½
E	-1 23/32	0

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B9

Subject: **Manufacturing Technology** **Time: 4 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Perform Calculations for Sine Bar and Sine Plate

Objective(s):

Upon completion of this unit the student will be able to:
a. Calculate gage block build up for 5" sine bar; and,
b. Calculate gage block build up for 10" sine plate.

Instructional Materials:

MASTER Handout (MFG-B9-HO1)
MASTER Handout (MFG-B9-HO2)
MASTER Laboratory Exercise (MFG-B9-LE)
MASTER Laboratory Aid (MFG-B9-LA)
MASTER Self-Assessment
Sine bar and sine plate
Set of gage blocks
Sample taper pins to measure

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Using Angular Measuring Systems"
Technology of Machine Tools, McGraw Hill Publishers, Latest Edition, "Angular Measurement"
Machinery's Handbook, Industrial Press, Latest Edition, "Sine-Bar"

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-B1 "Perform Basic Arithmetic Functions"
MFG-B6 "Understand Basic Trigonometry"

Introduction:

Sine bars and sine plates are common tools of today's machinist. Their use is simple and straightforward, and only the most basic trigonometry is required to achieve the desired result. Sine plates and sine bars are used to set machines for processing cuts other than right-angle cuts, and to measure angles that have already been cut.

Presentation Outline:

I. Calculate gage block build up for 5" sine bar
  A. Definitions
    1. Sine bar--a small (usually 5") hinged device of extremely hard metal, milled to tight tolerances, that is used to measure angles of up to 60°
    2. Gage block--a block of treated metal, used in groups to determine the angle of the cut on the sine bar or sine plate
  B. Actual Calculation
    1. Show how the trigonometric formula converts to practical application:

$$\text{Sine of angle} = \frac{\text{Side Opposite}}{\text{Hypotenuse}}$$

For a 5" sine bar, then:

$$\text{Sine of angle} = \frac{\text{Gage Block Height}}{5}$$

    2. Show the complementary use for measuring angles over 60°
    3. Checking tapers with the tangential formula: tan a/2 = TPF/24
    4. Gage block calculations using the two-column method
    5. Use of a sine bar constants table
  C. Notes on the care and handling of gage blocks
    1. Storage
      a. In the provided manufacturer's case
      b. Using preservative oil
    2. Wringing—how to put them together properly
    3. Minimal handling—body temperature affects accuracy

II. Calculate gage block build up for 10" sine plate
  A. Definitions
    1. Sine plate—a plate, usually made in multiples of 5", to which the workpiece is attached for measurement.
    2. Gage block, same as above
  B. Actual Calculations

III. Use of the sine bar and sine plate tables

Practical Application:

The students will be able to perform all angular measurement operations of the sine bar and sine plate. The students will also be able to handle and use gage blocks.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-B10) dealing with calculating for direct, simple and angular indexing.

MFG-B9-HO1
Perform Calculations for Sine Bar and Sine Plate
Attachment 1: **MASTER** Handout No. 1

Objective(s):

Upon completion of this unit the student will be able to:

a. Calculate gage block build up for 5" sine bar; and,
b. Calculate gage block build up for 10" sine plate.

Module Outline:

I. Calculate gage block build up for 5" sine bar
   A. Definitions
      1. Sine bar--a small (usually 5") hinged device of extremely hard metal, milled to tight tolerances, that is used to measure angles of up to 60°
      2. Gage block--a block of treated metal, used in groups to determine the angle of the cut on the sine bar or sine plate
   B. Actual Calculation
      1. Show how the trigonometric formula converts to practical application:

$$\text{Sine of angle} = \frac{\text{Side Opposite}}{\text{Hypotenuse}}$$

For a 5" sine bar, then:

$$\text{Sine of angle} = \frac{\text{Gage Block Height}}{5}$$

      2. Show the complementary use for measuring angles over 60°
      3. Checking tapers with the tangential formula: tan a/2 = TPF/24
      4. Gage block calculations using the two-column method
      5. Use of a sine bar constants table
   C. Notes on the care and handling of gage blocks
      1. Storage
         a. In the provided manufacturer's case
         b. Using preservative oil
      2. Wringing—how to put them together properly
      3. Minimal handling—body temperature affects accuracy
II. Calculate gage block build up for 10" sine plate
   A. Definitions
      1. Sine plate—a plate, usually made in multiples of 5", to which the workpiece is attached for measurement.
      2. Gage block, same as above
   B. Actual Calculations
III. Use of the sine bar and sine plate tables

MFG-B9-HO2
Perform Calculations for Sine Bar and Sine Plate
Attachment 2: **MASTER** Handout No. 2

Two-Column Gage Block Calculations

This example uses the following gage block set with two .050" wear blocks.

Federal Specification Set #4-88
(Courtesy of Brown & Sharpe Manufacturing Company)

.0625	.078125	.09375	.109375

.100025	.100050	.100075

.1001	.1002	.1003	.1004	.1005	.1006	.1007	.1008	.1009

.101	.102	.103	.104	.105	.106	.107
.108	.109	.110	.111	.112	.113	.114
.115	.116	.117	.118	.119	.120	.121
.122	.123	.124	.125	.126	.127	.128
.129	.130	.131	.132	.133	.134	.135
.136	.137	.138	.139	.140	.141	.142
.143	.144	.145	.146	.147	.148	.149

.050	.100	.150	.200	.250	.300	.350
.400	.450	.500	.550	.600	.650	.700
.750	.800	.850	.900	.950		

1.000	2.000	3.000	4.000

From this gage block set, we will calculate a gage block stack of 2.613 inches, which corresponds to the angle 31° 30'. The two-column method is quick and simple:

1. Subtract the two wear blocks;
2. Beginning with the right-most digit, eliminate the digits; and,
3. Calculate the remaining whole numbers.

Item		Individual Height	Total Height
1.	Required Height		2.613
2.	Wear Blocks (2)	.050	.100
	Remainder		2.513
3.	Eliminate Right-most digit	.113	.113
	Remainder		2.400
4.	Eliminate Right-most digit	.400	.400
	Remainder		2.000
5.	Calculate Whole Numbers	2.000	2.000
	Remainder		0

By using the two-column method, you will write down the blocks which you need as you calculate the height. To meet the required height, the above chart shows you that you need:

1. Two wear blocks;
2. One .113 block;
3. One .400 block; and,
4. One 2.000 block.

Name:________________________ Date:________________

MFG-B9-LE
Perform Calculations for Sine Bar and Sine Plate
Attachment 3: MASTER Laboratory Exercise

Using the set of gage blocks provided, solve the following problems. Be sure to demonstrate proper care and use of the gage blocks. Show all calculations for gage block height using the two-column method.

A. Using a 5" sine bar:

1. Set the angle of a cut at 32°.
2. Set the angle of a cut at 77°.
3. Set the angle of a cut at 3°.
4. Set the angle of a cut at 15° 30'.
5. Set the angle of a cut at 22°.

B. Using a 10" sine bar:

1. Set the angle of a cut at 32°.
2. Set the angle of a cut at 77°.
3. Set the angle of a cut at 3°.
4. Set the angle of a cut at 15° 30'.
5. Set the angle of a cut at 22°.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name____________________________ Date_______________

MFG-B9
Perform Calculations for Sine Bar and Sine Plate
Self-Assessment

Circle the letter preceding the correct answer.

1. Using a 5" sine bar, what gage block height produces an angle of 15°?
   A. 0.12941"
   B. 0.4829"
   C. 1.2941"
   D. 4.8296"
   E. None of the above answers is correct.

2. Using a 5" sine bar, what acute angle is produced by a gage block height of 1.7237"?
   A. 10° 20'
   B. 15° 15'
   C. 20° 10'
   D. 30°
   E. None of the above answers is correct.

3. Using a 5" sine bar, what gage block height produces an angle of 81°?
   A. 0.78215
   B. 0.15643
   C. 0.31286
   D. 1.23342
   E. None of the above answers is correct.

4. Using a 5" sine bar, what angle greater than 60° is produced by a gage block height of 3.3131"?
   A. 41° 30'
   B. 48° 30'
   C. 90°
   D. While answer B is the angle produced, it is not greater than 60°.
   E. None of the above answers is correct.

5. Using a 10" sine plate, what angle is produced by a gage block height of 7.0710?
   A. 15°
   B. 20°
   C. 45°
   D. 60°
   E. None of the above answers is correct.

6. Using a 10" sine plate, what gage block height produces an angle of 20°?
   - A. 0.34202"
   - B. 1.7101"
   - C. 3.4202"
   - D. 5.1303"
   - E. None of the above answers is correct.

7. What is the least number of blocks recommended to produce any angle for a sine bar or sine plate?
   - A. 1
   - B. 2
   - C. 3
   - D. 4
   - E. None of the above answers is correct.

8. Above what angle should a five-inch sine bar be rotated?
   - A. 30°
   - B. 45°
   - C. 60°
   - D. There is no critical angle for the five-inch sine bar.
   - E. None of the above answers is correct.

9. What is the TPF of a pin with a taper angle of 18°?
   - A. 7.416
   - B. 5.292
   - C. 3.801
   - D. 1.905
   - E. None of the above answers is correct.

10. Determine the taper angle of a piece 16 inches long, 9 inches at its base, and 3 inches at its top.
    - A. 5° 15' 39"
    - B. 10° 31' 18"
    - C. 21° 2' 36"
    - D. The problem cannot be solved from the information given.
    - E. None of the above answers is correct.

MFG-B9
Perform Calculations for Sine Bar and Sine Plate
Self-Assessment Answer Key

1. C
2. C
3. A
4. D
5. C
6. C
7. C
8. C
9. C
10. C

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B10

Subject: **Manufacturing Technology** **Time: 4 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Calculate for Direct, Simple, and Angular Indexing

Objective(s):

Upon completion of this unit the student will be able to:
a. Calculate for direct indexing;
b. Calculate for simple indexing (plain);
c. Calculate for angular indexing; and,
d. Use *Machinery's Handbook* for calculations.

Instructional Materials:

MASTER Handout (MFG-B10-HO)
MASTER Laboratory Exercise (MFG-B10-LE)
MASTER Laboratory Aid (MFG-B10-LA)
MASTER Self-Assessment
Scientific Calculator
Sample Index Plates
Samples of parts machined using dividing head and rotary table
Working indexing plates for demonstration and laboratory

References:

Machinery's Handbook, Industrial Press, Latest Edition, "Milling Machine Indexing"
Student's Shop Reference Handbook, Industrial Press, Latest Edition, "Machining Methods: Indexing"
Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Rotary Tables and Indexing Devices"

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-B1 "Perform Basic Arithmetic Functions"
MFG-B6 "Understand Basic Trigonometry"

Introduction:

Since the advent of CNC machining, the importance of indexing heads and rotary tables has declined for major applications, especially for helical applications. Nevertheless, there is still an important place in the industry for the older methods and the perforated wheels will continue to turn for many years.

Presentation Outline:

- I. Calculate for direct indexing
  - A. Define *direct indexing*: use of the indexing plate, without the worm gear, to obtain consistent angles
  - B. Discuss the various plate configurations
  - C. Explain the numerator/denominator of derived fractions in relation to the indexing plates and the circles on them
  - D. Discuss the uses and limitations of direct indexing
  - E. Show calculations based on the example in the student Self-Assessment or one of the sample index plates
    - 1. Discuss choice of circle on indexing plate
    - 2. Show possible divisions based on the number of holes in the circle
- II Calculate for simple indexing (plain)
  - A. Define *simple indexing*: use of the indexing plate, the crank, and the sector arms to obtain consistent angles that are not usually available through direct indexing
  - B. Discuss the 40:1 ratio of crank turns to spindle turns
  - C. Discuss the use of the indexing plate and sector arms in conjunction with the crank
  - D. Show calculations
    - 1. Simple formula: Indexing = 40/N, where N is the number of divisions to be cut, shows the necessary number of crank turns
    - 2. Show calculations for indexing plates resulting from fractional crank turns
- III. Calculate for angular indexing
  - A. Define *angular indexing*: use of degrees instead of divisions to determine the spacing of cuts
  - B. Show that one crank turn equals 9° or 540' of arc
  - C. Calculations
    - 1. Indexing = Degrees Required/9
    - 2. Indexing = Minutes Required/540
    - 3. 360° x 60'/degree = 21,600' in a circle
- IV. Use ***Machinery's Handbook*** for calculations
  - A. Discuss the differences between indexing plates from Brown & Sharpe and those of Cincinnati Standard Plate

B. Show tables of calculations and their uses

Practical Application:

Students will be able to properly calculate indexing for various applications.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-B11) dealing with the calculations necessary for turning tapers.

MFG-B10-HO
Calculate for Direct, Simple, and Angular Indexing
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Calculate for direct indexing;
b. Calculate for simple indexing (plain);
c. Calculate for angular indexing; and,
d. Use ***Machinery's Handbook*** for calculations.

Module Outline:

I. Calculate for direct indexing
    A. Define *direct indexing*: use of the indexing plate, without the worm gear, to obtain consistent angles
    B. Discuss the various plate configurations
    C. Explain the numerator/denominator of derived fractions in relation to the indexing plates and the circles on them
    D. Discuss the uses and limitations of direct indexing
    E. Show calculations based on the example in the student Self-Assessment or one of the sample index plates
        1. Discuss choice of circle on indexing plate
        2. Show possible divisions based on the number of holes in the circle

II Calculate for simple indexing (plain)
    A. Define *simple indexing*: use of the indexing plate, the crank, and the sector arms to obtain consistent angles that are not usually available through direct indexing
    B. Discuss the 40:1 ratio of crank turns to spindle turns
    C. Discuss the use of the indexing plate and sector arms in conjunction with the crank
    D. Show calculations
        1. Simple formula: Indexing = 40/N, where N is the number of divisions to be cut, shows the necessary number of crank turns
        2. Show calculations for indexing plates resulting from fractional crank turns

III. Calculate for angular indexing
    A. Define *angular indexing*: use of degrees instead of divisions to determine the spacing of cuts
    B. Show that one crank turn equals 9° or 540' of arc
    C. Calculations
        1. Indexing = Degrees Required/9

    2. Indexing = Minutes Required/540
    3. 360° x 60'/degree = 21,600' in a circle

IV. Use ***Machinery's Handbook*** for calculations
  A. Discuss the differences between indexing plates from Brown & Sharpe and those of Cincinnati Standard Plate
  B. Show tables of calculations and their uses

MFG-B10-LE
Calculate for Direct, Simple, and Angular Indexing
Attachment 2: MASTER Laboratory Exercise

I. Necessary Materials
   - A. Rotary table with indexing wheel
   - B. Dividing head
   - C. Several different sample pieces already cut by above methods

II. Instructor Demonstration

Using some of the sample pieces, the instructor will demonstrate the use of the dividing head and the rotary table.

III. Student Practice
   - A. Measure the sample pieces given to you by the instructor
   - B. Calculate the proper indexing for each piece
   - C. Set the rotary table and check it against the piece
   - D. Set the dividing head and check it against the piece
   - E. You should repeat III.B-D. for each of the types of indexing

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Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name____________________________ Date________________

MFG-B10
Calculate for Direct, Simple, and Angular Indexing
Self-Assessment

Circle the letter preceding the correct answer.

All exercises below use the following theoretical indexing plates:

Plate Number	Number of Holes per Circle
1	15-17-18-19-20-21
2	23-27-29-31-32-33
3	37-39-41-45-48-49

1. Using direct indexing, set up the machine to cut five faces.
   - A. Plate 1, Circle 15, Every three holes
   - B. Plate 1, Circle 20, Every four holes
   - C. Either A or B could be used
   - D. The problem requires angular indexing
   - E. None of the above answers is correct.

2. Using direct indexing, set up the machine to cut seven faces.
   - A. Plate 1, Circle 21, Every other hole
   - B. Plate 1, Circle 21, Every fourth hole
   - C. Plate 3, Circle 41, Every sixth hole
   - D. Plate 3, Circle 49, Every seventh hole
   - E. None of the above answers is correct.

3. Using direct indexing, set up the machine to cut fourteen faces.
   - A. Plate 1, Circle 21, Every other hole
   - B. Plate 2, Circle 29, Every other hole
   - C. Plate 3, Circle 41, Every third hole
   - D. The problem cannot be solved within the given conditions.
   - E. None of the above answers is correct.

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4 Using simple indexing, how many turns of the crank will produce ten flutes?

A. Two
B. Two and one-half
C. Five
D. Four
E. None of the above answers is correct.

5. Using simple indexing, how many turns of the crank will produce sixteen flutes?

A. Two
B. Two and one-half
C. Three
D. Four
E. None of the above answers is correct.

6. What is the correct setting for one-quarter turn where the highest accuracy is required?

A. Plate 1, Circle 16, Every fourth hole
B. Plate 2, Circle 32, Every eighth hole
C. Plate 3, Circle 48, Every twelfth hole
D. The plate used does not affect the accuracy of the angle.
E. None of the above answers is correct.

7. The blueprint requires that certain holes be drilled 45° apart. How many turns of the crank does this require?

A. Two
B. Three
C. Four
D. Five
E. None of the above answers is correct.

8. The blueprint requires that certain holes be drilled 22° 30' apart, but the precision is not of the highest order. Calculate the indexing.

A. Two cranks; Plate 1, Circle 16, Every eighth hole
B. Two cranks; Plate 2, Circle 32, Every sixteenth hole
C. Two cranks; Plate 3, Circle 48, Every twenty-fourth hole
D. Either A or C is acceptable.
E. None of the above answers is correct.

9. What is the indexing for five holes drilled 18° 45' apart?
   A. 2 1/12
   B. 2 3/36
   C. 2 4/48
   D. All of the above answers are mathematically the same; however, only C is applicable because of the set of indexing plates used.
   E. None of the above answers is correct.

10. What is the indexing for three holes 27° 12' apart?
   A. 1/15
   B. 1/45
   C. 3/16
   D. 42/49
   E. None of the above answers is correct.

MFG-B10
Calculate for Direct, Simple, and Angular Indexing
Self-Assessment Answer Key

1. C
2. D
3. D
4. D
5. B
6. C
7. D
8. D
9. D
10. B

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B11

Subject: **Manufacturing Technology** **Time: 4 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Perform Calculations Necessary for Turning Tapers

Objective(s):

Upon completion of this unit the student will be able to:
a. Calculate tail stock offset; and,
b. Determine unknowns (tpf, small and/or large diameters, etc.) for taper turning.

Instructional Materials:

MASTER Handout (MFG-B11-HO)
MASTER Laboratory Aid (MFG-B11-LA)
MASTER Self-Assessment

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Cutting Tapers"
Student's Shop Reference Handbook, Industrial Press, Latest Edition, "Tapers and Keys"
Machinery's Handbook, Industrial Press, Latest Edition, "Tapers"

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-B1	"Perform Basic Arithmetic Functions"
MFG-B6	"Understand Basic Trigonometry"

Introduction:

The tapered plug and hole are two of the oldest tools of industry. Wooden casks, holding hundreds of gallons of wine or beer, were tapped with hollow wooden tapers for centuries. The modern taper has, of course, thousands of other uses; because they are so common, every machinist must learn how to properly turn a tapered plug, and how to bore a tapered hole. This module is concerned only with calculations for tapered plugs.

Presentation Outline:

I. Calculate tail stock offset
    A. Definitions
        1. Taper angles
            a. Included angle: The total angle of the taper measured from *both sides* of the taper
            b. Angle from center line: The angle of the taper measured from the center line of the workpiece on *one side* of the taper; therefore, one-half the included angle
        2. Tpf: Taper per foot, inches of decrease in diameter per foot of taper length
        3. Tpi: Taper per inch, inches of decrease in diameter per inch of taper length
        4. Metric ratio: 1 millimeter per unit of work length
        5. Tail stock offset: The distance from the center of the head stock to the center of the tailstock that is required to cut a taper
    B. Calculations, where L is the Length of the workpiece; L_T is the Length of the taper; D is the large diameter of the taper; d is the small diameter at the end of the taper; k is amount of taper per unit length; and α is the angle from the center line
        1. $\text{Offset} = (\text{tpi} \times L)/2$
        2. $\text{Offset} = (\text{tpf} \times L)/24$
        3. $\text{Offset} = [L \times (D-d)]/2L_T$
        4. $\tan \alpha = \text{tpf}/24$
        5. $\text{Metric Offset} = [(D-d)/2L_T] \times L$
        6. Metric Taper: $D-d = L_T/k$

II. Determine unknowns (tpf, small and/or large diameters, etc.) for taper turning using the formulae listed in I.B.

Practical Application:

Students should complete the Self-Assessment at the end of the chapter in the text.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-B12) dealing with calculating depth of cuts for round surfaces.

MFG-B11-HO
Perform Calculations Necessary for Turning Tapers
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Calculate tail stock offset; and,
- b. Determine unknowns (tpf, small and/or large diameters, etc.) for taper turning.

Module Outline:

- I. Calculate tail stock offset
  - A. Definitions
    - 1. Taper angles
      - a. Included angle: The total angle of the taper measured from *both sides* of the taper
      - b. Angle from center line: The angle of the taper measured from the center line of the workpiece on *one side* of the taper; therefore, one-half the included angle
    - 2. Tpf: Taper per foot, inches of decrease in diameter per foot of taper length
    - 3. Tpi: Taper per inch, inches of decrease in diameter per inch of taper length
    - 4. Metric ratio: 1 millimeter per unit of work length
    - 5. Tail stock offset: The distance from the center of the head stock to the center of the tailstock that is required to cut a taper
  - B. Calculations, where L is the Length of the workpiece; L_T is the Length of the taper; D is the large diameter of the taper; d is the small diameter at the end of the taper; k is amount of taper per unit length; and α is the angle from the center line
    - 1. Offset = (tpi x L)/2
    - 2. Offset = (tpf x L)/24
    - 3. Offset = $[L \times (D-d)]/2L_T$
    - 4. Tan α = tpf/24
    - 5. Metric Offset = $[(D-d)/2L_T] \times L$
    - 6. Metric Taper: $D-d = L_T/k$
- II. Determine unknowns (tpf, small and/or large diameters, etc.) for taper turning using the formulae listed in I.B.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
   a. No loose clothing, including ties;
   b. Long hair properly stowed;
   c. No jewelry;
   d. Hard, closed-toe shoes;
   e. Eye protection (safety glasses); and,
   f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name_____________________________ Date_______________

MFG-B11
Perform Calculations Necessary for Turning Tapers
Self-Assessment

Solve for the requested variable. Show all work.

1. The angle from the center line is 14° 2". What is the taper per foot?

2. The desired tpi is 0.1250. What is the included angle of the taper?

3. The large diameter of the taper is 50 mm; the small diameter is 20 mm; and the length of the taper is 30 mm. What is the taper of the workpiece?

4. The large diameter is 100 mm; the small diameter, 60 mm; the taper length is 200 mm; the workpiece is 500 mm long. What is the required offset?

5. The offset is 0.500 inch; the length of the workpiece is 18 inches. What is the tpi?

6. The tpi is 0.275; the length of the workpiece is 6 inches. What is the offset?

7. The tpf is 0.275; the offset is 0.1375. What is the length of the workpiece?

8. The tpf is 1.250; the length of the workpiece is 6 inches. What is the offset?

9. The large taper diameter is 3 inches; the small taper diameter is 2.75 inches. The length of the taper is 1 inch; the workpiece is 8 inches long. What is the offset?

10. The large taper diameter is 2 inches; the small diameter, 1.5 inches. The workpiece is 6 inches long. The offset is 0.625 inch. What is the length of the taper?

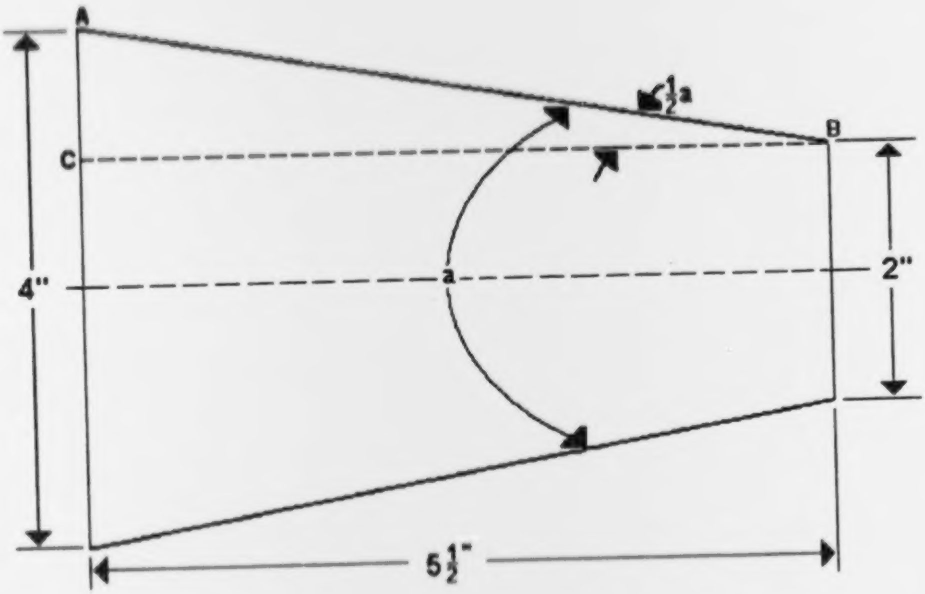

A
B
C
a
½a
4"
2"
5½"

Diagram 1, MFG-B11

MFG-B11

Perform Calculations Necessary for Turning Tapers

Self-Assessment Answer Key

1. 6
2. 7° 8"
3. 1:1
4. 50 mm
5. 0.0556
6. 0.825
7. 12"
8. 0.3125"
9. 1"
10. 2.400"

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B12

Subject: **Manufacturing Technology** **Time: 2 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Calculate Depth of Cut for Round Surfaces

Objective(s):

Upon completion of this unit the student will be able to:

a. Calculate depth of cut for flats to be machined on cylindrical pieces; and,
b. Calculate depth of cut for keyways which are machined on cylindrical pieces.

Instructional Materials:

MASTER Handout (MFG-B12-HO1)
MASTER Handout (MFG-B12-HO2)
MASTER Laboratory Aid (MFG-B12-LA)
MASTER Self-Assessment

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Arbor and Shop Presses"
Student's Shop Reference Handbook, Industrial Press, Latest Edition, "Tapers and Keys"
Machinery's Handbook, Industrial Press, Latest Edition, "Keys and Keyseats"

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-B1	"Perform Basic Arithmetic Functions"
MFG-B6	"Understand Basic Trigonometry"

Introduction:

An important component of machinery is the *key*. Among other things, keys facilitate the operation of pulleys on axles by holding the pulley in place radially. Similarly, flats on axles provide a stabilizing surface for rotating parts. There are other uses for flats as well, including insuring that parts are installed in the proper order.

Presentation Outline:

- I. Calculate depth of cut for flats to be machined on cylindrical pieces
- II. Calculate depth of cut for keyways which are machined on cylindrical pieces
  - A. Definitions
    - 1. **Broach**: a multi-toothed cutter used to cut irregular internal shapes as well as external features
    - 2. **Keyseat**: a slot that is designed to accommodate a protrusion (key) cut into a workpiece either internally or externally; sometimes called **keyway**
  - B. Discuss the process of keyway broaching
  - C. Calculate depth of cut and discuss broach selection
    - 1. Broaches
      - a. Selection
      - b. Common problems
    - 2. ***Machinery's Handbook*** table: "Finding Depth of Keyseat And Distance from Top of Key to Bottom of Shaft"
    - 3. Keyseat formulae (See **MFG-B12-HO2)**
      - a. Cutter Feed Depth: $M + D$
      - b. Precision Formula for *M*: $M = \frac{1}{2}(S - \sqrt{S^2 - E^2})$
      - c. Non-precision Formula for *M*: $M = E^2/4S$
      - d. Verification Formula: $J = [S - (M + D)] + C$

Practical Application:

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-C1) dealing with identifying the basic layout of drawings.

MFG-B12-HO1
Calculate Depth of Cut for Round Surfaces
Attachment 1: MASTER Handout No. 1

Objective(s):

Upon completion of this unit the student will be able to:

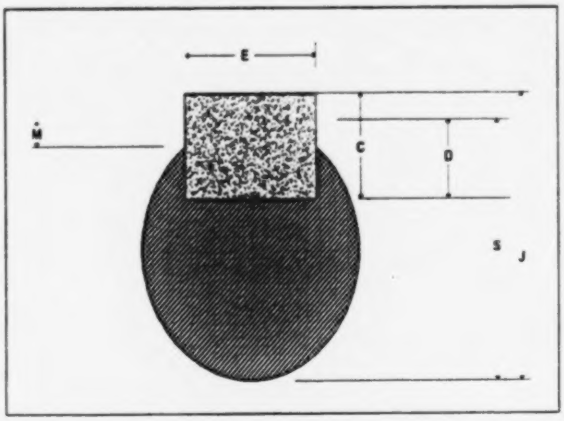
a. Calculate depth of cut for flats to be machined on cylindrical pieces; and,

b. Calculate depth of cut for keyways which are machined on cylindrical pieces.

Module Outline:

- I. Calculate depth of cut for flats to be machined on cylindrical pieces
- II. Calculate depth of cut for keyways which are machined on cylindrical pieces
    - A. Definitions
        - 1. **Broach**: a multi-toothed cutter used to cut irregular internal shapes as well as external features
        - 2. **Keyseat**: a slot that is designed to accommodate a protrusion (key) cut into a workpiece either internally or externally; sometimes called **keyway**
    - B. Discuss the process of keyway broaching
    - C. Calculate depth of cut and discuss broach selection
        - 1. Broaches
            - a. Selection
            - b. Common problems
        - 2. *Machinery's Handbook* table: "Finding Depth of Keyseat And Distance from Top of Key to Bottom of Shaft"
        - 3. Keyseat formulae (See MFG-B12-HO2)
            - a. Cutter Feed Depth: $M + D$
            - b. Precision Formula for *M:* $M = \frac{1}{2}(S - \sqrt{S^2 - E^2})$
            - c. Non-precision Formula for *M*: $M = E^2/4S$
            - d. Verification Formula: $J = [S - (M + D)] + C$

MFG-B12-HO2
Calculate Depth of Cut for Round Surfaces
Attachment 2: MASTER Handout No. 2



MFG-B12HO
Calculate Depth of Cut For Round Surfaces
Reference Handout

MFG-B12-LA

Calculate Depth of Cut for Round Surfaces

Attachment 3: MASTER Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name______________________________ Date________________

MFG-B12
Calculate Depth of Cut for Round Surfaces
Self-Assessment

Use the formulas to solve the following problems. (See attached Reference Handout - MFG-B12-HO2.) Show all work.

1. Given that S = 3 in and E = 3/4 in, what is M?
Precision Answer: _____
Non-Precision Answer: _____

2. Given that S = 6 in and E = 1 in, what is M?
Precision Answer:_____
Non-Precision Answer:_____

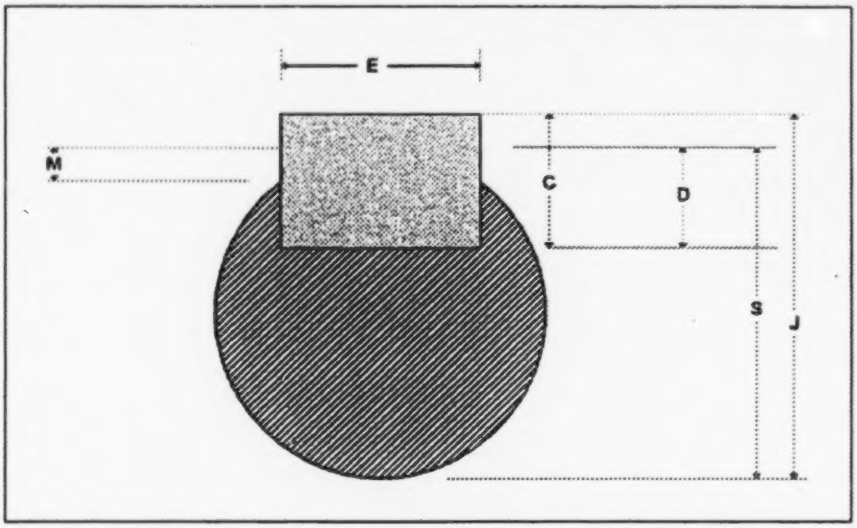
3. Given that S = 4cm, E = 7.5mm, D = 5.0mm, and C = 7.5mm; what is J?
Precision Answer:_____
Non-Precision Answer:_____

4. Given that S = 8 in, E = 3 in, D = 2 in, and C = 4 in; what is J?
Precision Answer:_____
Non-Precision Answer:_____

Circle the correct answer:

5. Technician A says that galling can be caused by using an improper coolant. Technician B says that too few teeth in cutting contact can also cause galling. Who is correct?
   - A. Technician A only
   - B. Technician B only
   - C. Both Technicians A and B
   - D. Neither Technician A nor B

6. The technicians are discussing the removal of a stuck broach. Technician A says that the broach and the workpiece must be removed from the broaching machine as a unit. Technician B says that they may have to turn the workpice on a lathe to free the broach. Who is correct?
   - A. Technician A only
   - B. Technician B only
   - C. Both Technicians A and B
   - D. Neither Technician A nor B



MAC-B12HO
Calculate Depth of Cut For Round Surfaces
Reference Handout

MFG-B12
Calculate Depth of Cut for Round Surfaces
Self-Assessment Answer Key

1. P: 0.0476 in
   N: 0.0469 in

2. P: 0.0420 in
   N: 0.0417 in

3. P: 42.1453 mm
   N: 42.1484 mm

4. P: 9.7081 in
   N: 9.7187 in

5. A

6. C

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B13

Subject: **Manufacturing Technology** **Time: 6 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Use All Functions on a Scientific Calculator

Objective(s):

Upon completion of this unit the student will be able to:

a. Name the function keys that are most commonly found on any given "scientific calculator";
b. Enter numbers into a calculator and understand how the scientific calculator displays numbers;
c. Complete addition, subtraction, multiplication, and division operations working with whole numbers, fractions, mixed numbers, decimals, percentages, powers, roots, and trigonometric functions utilizing the scientific calculator;
d. Understand the order of operation(s) of the scientific calculator; and,
e. Use the memory and parentheses functions of a scientific calculator to solve simple formulas.

Instructional Materials:

MASTER Handout (MFG-B13-HO)
MASTER Self-Assessment
Sufficient Scientific Calculators.

(**Note:** The instructor needs to be familiar with the particulars of the specific scientific calculator being used.)

References:

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-B1	"Perform Basic Arithmetic Functions"
MFG-B2	"Convert Fractions/Decimals"
MFG-B3	"Convert Metric/English Measurements"
MFG-B4	"Perform Basic Algebraic Operations"

Introduction:

If only Blase Pascal could see us now. His little adding machine, the marvel of its day, is now almost as primitive as a stylus and a wax-board. Today, we carry around in our shirt pockets electronic brains capable of the most complex of mathematical functions. But there is a price: the diminutive machines require operators who understand how to talk to them in their own language. Monsieur Pascal turned wheels to operate his machine, clockwise or counter-clockwise, depending on whether he was adding or subtracting. We push button after button, *in the correct order,* or nothing works. This lesson is designed to familiarize you with the operation of one of these adding devices: the scientific calculator.

Presentation Outline:

I. Introduction to the Scientific Calculator
  A. Explanation of the function keys that are most commonly found on any given "scientific calculator"
  B Explanation of how to enter numbers into a scientific calculator and of how the calculator displays numbers

II. Using the Scientific Calculator
  A. How to add, subtract, multiply, and divide whole numbers, fractions, mixed numbers, decimals, percentages, powers, roots, and trigonometric functions
  B. Introduction to the order of operation(s)
  C. How to use the memory and parenthetical functions to solve simple formulas

Practical Application:

Students will be able to use all functions on a scientific calculator as needed to solve problems and conduct operations encountered in the manufacturing industry.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-B14) dealing with solving engineering equations.

MFG-B13
Use All Functions on a Scientific Calculator
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Name the function keys that are most commonly found on any given "scientific calculator";
- b. Enter numbers into a calculator and understand how the scientific calculator displays numbers;
- c. Complete addition, subtraction, multiplication, and division operations working with whole numbers, fractions, mixed numbers, decimals, percentages, powers, roots, and trigonometric functions utilizing the scientific calculator;
- d. Understand the order of operation(s) of the scientific calculator; and,
- e. Use the memory and parentheses functions of a scientific calculator to solve simple formulas.

Module Outline:

- I. Introduction to the Scientific Calculator
  - A. Explanation of the function keys that are most commonly found on any given "scientific calculator"
  - B Explanation of how to enter numbers into a scientific calculator and of how the calculator displays numbers
- II. Using the Scientific Calculator
  - A. How to add, subtract, multiply, and divide whole numbers, fractions, mixed numbers, decimals, percentages, powers, roots, and trigonometric functions
  - B. Introduction to the order of operation(s)
  - C. How to use the memory and parenthetical functions to solve simple formulas

Name________________________ Date______________

MFG-B13
Use All Functions on a Scientific Calculator
Self-Assessment

Note: Instructor should design this test to the specifics of the scientific calculator being taught.

1.

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-B14

Subject: **Manufacturing Technology** **Time: 6 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Solve Static Systems for Resultant Force

Objective(s):

Upon completion of this module, the student will:
a. Know the difference between weight and mass;
b. Understand the basics of vector mathematics and torque equations;
c. Understand the units of mechanical forces; and,
d. Use mathematics to predict resultant force from multiple vectors.

Instructional Materials:

MASTER Handout (MFG-B14-HO)
MASTER Self-Assessment
Lever scale
Something to weigh on scale

References:

Principles of Technology, Force, CORD, Waco, TX, Latest Edition
Student's Shop Reference Handbook, Hoffman, Edward G.; Industrial Press, Inc., 200 Madison Avenue, NY, NY, Latest Edition

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Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-B1	"Perform Basic Arithmetic Functions"
MFG-B2	"Convert Fractions/Decimals"
MFG-B3	"Convert Metric/English Measurements"
MFG-B4	"Perform Basic Algebraic Operations"
MFG-B5	"Use Practical Geometry"
MFG-B6	"Understand Basic Trigonometry"
MFG-B8	"Use Coordinate Systems"
MFG-B13	"Use All Functions on a Scientific Calculator"

Introduction:

Nothing moves without force. *Force is the main component of motion.* Therefore, means of calculating, measuring, and controlling forces are the main tools by which work is done. And while our tools have become more sophisticated and efficient than stone knives and rolling logs, they really do not perform different functions. All of them apply force to a material to change that material in some way. For example, a shear is a large machine used to cut metal. It does nothing different from the flint knapper's antler. The scale is different, but the principle is identical.

Presentation Outline:

I. Mass vs. Weight
    A. Mass is constant.
    B. Weight varies by location.
    C. Weight is dependent on both mass and gravity.
II. Units of Mechanical Force
    A. English pound-foot
    B. SI Newton-meter
    C. Fractional units of both systems
III. Vectors and Torque
    A. *Vector:* a physical quantity having both direction and magnitude
    B. *Torque:* a force applied to a lever arm on an axis of rotation
    C. *Scalar:* a physical quantity having only magnitude
IV. Mathematics of Force
    A. Adding and Subtracting collinear forces
    B. Adding and Subtracting oblique forces
    C. Torque Solutions
    D. Stress that force is a vector, ***not*** a scalar

Practical Application:

This module prepares the student for the mathematics of the workplace wherever forces are involved.

Evaluation and/or Verification:

Students should demonstrate a proficiency of 90% on the Self-Assessment found at the end of this module.

Summary:

Review the main lesson points and answer student questions. Use the lever scale to demonstrate the applications of torque mathematics.

Next Lesson Assignment:

MASTER Technical Module (MFG-B15) dealing with determining strength of materials for various applications.

MFG-B14-HO
Solve Static Systems For Resultant Force
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this module, the student will:

a. Know the difference between weight and mass;
b. Understand the basics of vector mathematics and torque equations;
c. Understand the units of mechanical forces; and,
d. Use mathematics to predict resultant force from multiple vectors.

Module Outline:

I. Mass vs. Weight
    A. Mass is constant.
    B. Weight varies by location.
    C. Weight is dependent on both mass and gravity.
II. Units of Mechanical Force
    A. English pound-foot
    B. SI Newton-meter
    C. Fractional units of both systems
III. Vectors and Torque
    A. *Vector:* a physical quantity having both direction and magnitude
    B. *Torque:* a force applied to a lever arm on an axis of rotation
    C. *Scalar:* a physical quantity having only magnitude
IV. Mathematics of Force
    A. Adding and Subtracting collinear forces
    B. Adding and Subtracting oblique forces
    C. Torque Solutions
    D. Stress that force is a vector, *not* a scalar

Name______________________________ Date_________________

MFG-B14
Solve Static Systems For Resultant Force
Self-Assessment

Answer the following questions:

1. A two-bar nutcracker exerts opposing collinear forces of 50 pounds left and 45 pounds right. Considering only the forces, what is the position of the nutcracker's bars at rest?
   A. Dead center
   B. All the way to the left
   C. All the way to the right
   D. Insufficient information to decide
   E. None of the above answers is correct.

2. What is torque?
   A. A physical quantity having both direction and magnitude
   B. A force applied to a lever arm on an axis of rotation
   C. A physical quantity having only magnitude
   D. A physical quantity having only direction
   E. None of the above answers is correct.

3. What is a vector?
   A. A physical quantity having both direction and magnitude
   B. A force applied to a lever arm on an axis of rotation
   C. A physical quantity having only magnitude
   D. A physical quantity having only direction
   E. None of the above answers is correct.

4. What is a scalar?
   A. A physical quantity having both direction and magnitude
   B. A force applied to a lever arm on an axis of rotation
   C. A physical quantity having only magnitude
   D. A physical quantity having only direction
   E. None of the above answers is correct.

5. Two horses pulling in line are attempting to move a cart. The lead horse pulls at 700 lbs, north; the second horse pulls at 600 lbs, north. What is the net force on the cart?
   - A. 100 lbs, north.
   - B. 700 lbs, north
   - C. 600 lbs, north
   - D. 1300 lbs.
   - E. None of the above answers is correct.

6. Two people are moving an inoperative car. The two people are 90° apart, relative to the point where their ropes attach to the bumper. Person A exerts 100 lbs, southeast while Person B exerts 100 lbs, southwest. What is the resultant force on the car?
   - A. 200 lbs, south
   - B. 141.42 lbs, south
   - C. 141.42 lbs, southeast
   - D. 141.42 lbs, southwest
   - E. None of the above answers is correct.

7. Gear A has a crank handle set 12 inches from its axis of rotation. If a force of 10 lbs, ccw, is applied to the handle, what is the torque?
   - A. 10 lb-ft, ccw
   - B. 12 lb-ft, ccw
   - C. 120 lb-ft, ccw
   - D. 10 n-m, ccw
   - E. None of the above answers is correct.

8. Gear B is turned by Gear A from Problem 7, but Gear B has a radius of 18 inches. What is the torque on Gear B's axis?
   - A. 10 lb-ft, ccw
   - B. 10 lb-ft, cw
   - C. 15 lb-ft, ccw
   - D. 15 lb-ft, cw
   - E. None of the above answers is correct.

9. In Problem 6, how can the people moving the car increase their ability to pull the vehicle?

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10. Technician A says that using a longer wrench on a nut will generate more torque with the same amount of force. Technician B says that pushing harder (exerting more force) on the shorter wrench will accomplish the same thing. Which technician is correct?

A. Technician A only
B. Technician B only
C. Both Technicians A and B
D. Neither Technician A nor B

MFG B-14
Solve Static Systems for Resultant Force
Self-Assessment Answer Key

1. B

2. B

3. A

4. C

5. E
(Although the 1300 lbs. would be correct, there is no direction indicated. Therefore, E is the correct answer.)

6. B

7. A

8. D
(Remember that adjacent gears turn in *opposite* directions.)

9. By moving closer together. The greatest force (200 lbs, south) could be exerted by their pulling on a *single* rope!

10. C

MANUFACTURING TECHNOLOGY SERIES
MASTER Technical Module No. MFG-B15

Subject: **Manufacturing Technology** **Time: 8 Hrs.**

Duty: **Apply Mathematical Concepts**
Task: Determine Strengths of Materials for Various Applications

Objective(s):

Upon completion of this module, the student will be able to:
a. Recognize the basic types of material strengths;
b. Recognize the types of simple physical stresses to which materials are subjected; and,
c. Determine the strength of a given material in relation to the appropriate physical stress.

Instructional Materials:

MASTER Handout (MFG-B15-HO)
MASTER Reference Sheet (MFG-B15-RS)
MASTER Self-Assessment

References:

Machinery's Handbook, Industrial Press, Latest Edition

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-B1	"Perform Basic Arithmetic Functions"
MFG-B2	"Convert Fractions/Decimals"
MFG-B3	"Convert Metric/English Measurements"
MFG-B4	"Perform Basic Algebraic Operations"
MFG-B5	"Use Practical Geometry"
MFG-B6	"Understand Basic Trigonometry"
MFG-B7	"Calculate Speeds and Feeds for Machining"
MFG-B8	"Use Coordinate Systems"
MFG-B9	"Perform Calculations for Sine Bar and Sine Plate"
MFG-B10	"Calculate for Direct, Simple, and Angular Indexing"
MFG-B11	"Perform Calculations Necessary for Turning Tapers"
MFG-B12	"Calculate Depth of Cut for Round Surfaces"
MFG-B13	"Use All Functions on a Scientific Calculator"

MFG-B14 "Solve Static Systems for Resultant Force"

Introduction:

In the 1970s, the federal government introduced mileage standards for automobiles. The automobile industry responded by making cars which were first smaller, then lighter. Why didn't the automobile industry just start carving cars out of balsa wood? This would have made incredibly light vehicles and allowed them to exceed the mileage requirements. But balsa is not strong enough to manufacture cars, pure and simple.

All industries respond in a similar manner. Materials for parts are determined by several factors, but their strengths in response to the stresses imposed on them is paramount.

Presentation Outline:

- I. Stress and Deformation
    - A. Factors affecting strengths
        - 1. Temperature
        - 2. Time element
            - a. Static
            - b. Impact
            - c. Cyclic
        - 3. Corrosive vapors or liquids
        - 4. Pressure differential
    - B. Types of simple stresses
        - 1. Direct tension
        - 2. Direct compression
        - 3. Bending
        - 4. Direct shear
        - 5. Torsion
- II. Properties of Materials
    - A. Yield strength (S_y)
    - B. Ultimate (tensile) strength (S_u)
    - C. Modulus of elasticity (Young's Modulus) (E)
    - D. Poisson's ration (μ)
    - E. Compression
        - 1. Compressive yield strength (S_{cy})
        - 2. Compressive ultimate strength (S_{cu})
    - F. Shear
        - 1. Shear yield strength (S_{sy})
        - 2. Shear ultimate strength (S_{su})
        - 3. Modulus of rigidity (G)
    - G. Fatigue

- III. Moments of Inertia
  - A. Simple forms
    - 1. Solid square cross-section
    - 2. Hollow square cross-section
    - 3. Solid rectangular cross-section
    - 4. Hollow rectangular cross-section
    - 5. Solid circular cross-section
    - 6. Hollow circular cross-section
    - 7. Standard I-beam (flange slope of 1/6)
  - B. Breaking down complex forms into simple forms
  - C. Combining results for calculation
- IV. Use of *Machinery's Handbook*
- V. Problems of Torque
- VI. Calculate Simple Stresses
  - A. Definitions (from *Machinery's Handbook*)
    - 1. A is the cross-sectional area in square inches
    - 2. F is the external force in pounds
    - 3. I is the moment of inertia in inches^4
    - 4. J is the polar moment of inertia in inches^4
    - 5. M is the bending moment in inch-pounds
    - 6. T is the torsional moment in inch-pounds
    - 7. V is the shearing force in pounds
    - 8. Z is the section modulus in inches^3
    - 9. Z_p is the polar section modulus in inches^3
    - 10. σ is the simple normal stress in pounds per inch^2
    - 11. τ is the simple shear stress in pounds per inch^2
  - B. Direct tension
  - C. Direct compression
  - D. Bending
    - 1. General
    - 2. Rectangular beams
    - 3. Solid circular beams
  - E. Direct shear
  - F. Torsion
- VII. Design of Joints
  - A. Load
  - B. Length
  - C. Supports
  - D. Shape of joined members
- VIII. Fastening Techniques

MFG-B15-HO
Determine Strength of Materials For Various Applications
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module, the student will be able to:

- a. Recognize the basic types of material strengths;
- b. Recognize the types of simple physical stresses to which materials are subjected; and,
- c. Determine the strength of a given material in relation to the appropriate physical stress.

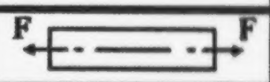
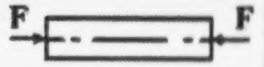
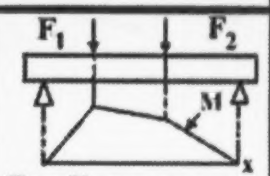
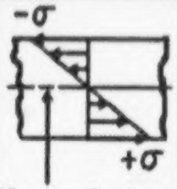
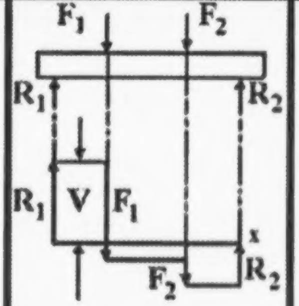
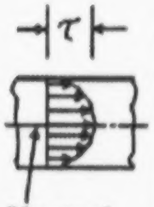
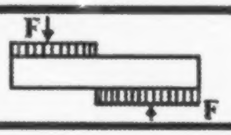
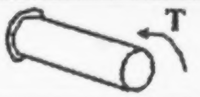
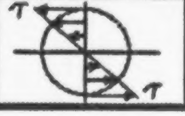
Module Outline:

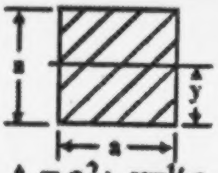
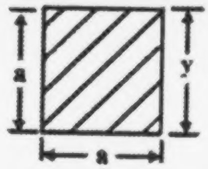
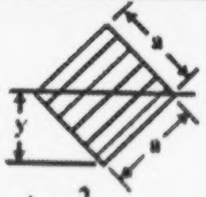
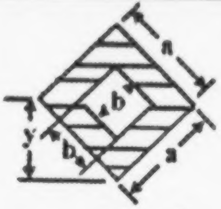
- I. Stress and Deformation
  - A. Factors affecting strengths
    - 1. Temperature
    - 2. Time element
      - a. Static
      - b. Impact
      - c. Cyclic
    - 3. Corrosive vapors or liquids
    - 4. Pressure differential
  - B. Types of simple stresses
    - 1. Direct tension
    - 2. Direct compression
    - 3. Bending
    - 4. Direct shear
    - 5. Torsion
- II. Properties of Materials
  - A. Yield strength (S_y)
  - B. Ultimate (tensile) strength (S_u)
  - C. Modulus of elasticity (Young's Modulus) (E)
  - D. Poisson's ration (μ)
  - E. Compression
    - 1. Compressive yield strength (S_{cy})
    - 2. Compressive ultimate strength (S_{cu})
  - F. Shear
    - 1. Shear yield strength (S_{sy})
    - 2. Shear ultimate strength (S_{su})
    - 3. Modulus of rigidity (G)
  - G. Fatigue
- III. Moments of Inertia

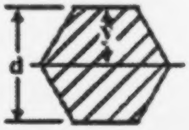
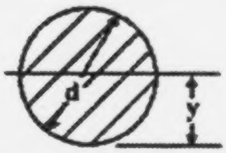
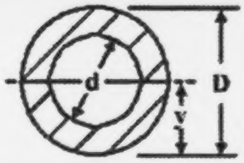
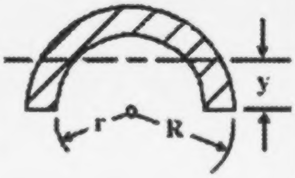
- A. Simple forms
    - 1. Solid square cross-section
    - 2. Hollow square cross-section
    - 3. Solid rectangular cross-section
    - 4. Hollow rectangular cross-section
    - 5. Solid circular cross-section
    - 6. Hollow circular cross-section
    - 7. Standard I-beam (flange slope of 1/6)
- B. Breaking down complex forms into simple forms
- C. Combining results for calculation

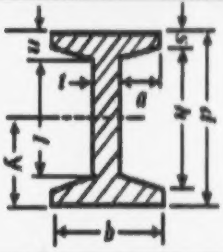
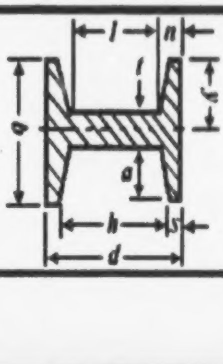
- IV. Use of ***Machinery's Handbook***
- V. Problems of Torque
- VI. Calculate Simple Stresses
    - A. Definitions (from ***Machinery's Handbook***)
        - 1. A is the cross-sectional area in square inches
        - 2. F is the external force in pounds
        - 3. I is the moment of inertia in inches^4
        - 4. J is the polar moment of inertia in inches^4
        - 5. M is the bending moment in inch-pounds
        - 6. T is the torsional moment in inch-pounds
        - 7. V is the shearing force in pounds
        - 8. Z is the section modulus in inches^3
        - 9. Z_p is the polar section modulus in inches^3
        - 10. σ is the simple normal stress in pounds per inch^2
        - 11. τ is the simple shear stress in pounds per inch^2
    - B. Direct tension
    - C. Direct compression
    - D. Bending
        - 1. General
        - 2. Rectangular beams
        - 3. Solid circular beams
    - E. Direct shear
    - F. Torsion
- VII. Design of Joints
    - A. Load
    - B. Length
    - C. Supports
    - D. Shape of joined members
- VIII. Fastening Techniques

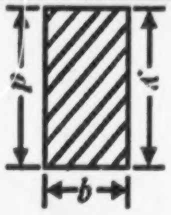
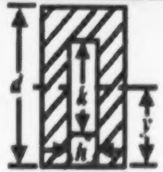
MFG-B15RS
Determine Strength of Materials For Various Applications
Attachment 2: MASTER Reference Sheet

Case	Type of Loading	Illustration	Stress Distribution	Stress Equations
1	Direct tension		Uniform	$\sigma = \frac{F}{A}$ (9)
2	Direct Compression		Uniform	$\sigma = -\frac{F}{A}$ (10)
3	Bending	 Bending moment diagram	 Neutral plane	$\sigma = \pm\frac{M}{Z} = \pm\frac{My}{I}$ (11)
4	Bending	 F_1 F_2 R_1 R_2 R_1 V F_1 x F_2 R_2 Shearing force diagram	 Neutral Plane	For beams of rectangular cross-section: $\tau = \frac{3V}{2A}$ (12) For beams of solid circular cross-section: $\tau = \frac{4V}{3A}$ (13) For wide flange and I beams (approximately): $\tau = \frac{V}{a}$ (14)
5	Direct shear		Uniform	$\tau = \frac{F}{A}$ (15)
6	Torsion			$\tau = \frac{T}{Zp} = \frac{Tc}{J}$ (16)

Section A = area y = distance from axis to extreme fiber	Moment of Inertia I	Section Modules $Z = \frac{I}{y}$	Radius of Gyration $k = \sqrt{\frac{I}{A}}$
 $A = a^2$; $y = \frac{1}{2}a$	$\frac{a^4}{12}$	$\frac{a^3}{6}$	$\frac{a}{\sqrt{12}} = 0.289a$
 $A = a^2$; $y = a$	$\frac{a^4}{3}$	$\frac{a^3}{3}$	$\frac{a}{\sqrt{3}} = 0.577a$
 $A = a^2$ $y = \frac{a}{\sqrt{2}} = 0.707a$	$\frac{a^4}{12}$	$\frac{a^3}{6\sqrt{2}} = 0.118a^3$	$\frac{a}{\sqrt{12}} = 0.289a$
 $A = a^2 - b^2$ $y = \frac{a}{\sqrt{2}} = 0.707a$	$\frac{a^4 - b^4}{12}$	$\frac{\sqrt{2}\,(a^4 - b^4)}{12a}$ $= 0.118\,\frac{a^4 - b^4}{a}$	$\sqrt{\frac{a^2 + b^2}{12}}$ $= 0.289\sqrt{a^2 + b^2}$

Section	Area of Section, A	Distance from Neutral Axis to Extreme Fiber, y
	$\frac{3d^2 \tan 30°}{2} = 0.866d^2$	$\frac{d}{2}$
	$\frac{\pi d^2}{4} = 0.7854d^2$	$\frac{d}{2}$
	$\frac{\pi(D^2 - d^2)}{4}$ $= 0.7854(D^2 - d^2)$	$\frac{D}{2}$
	$\frac{\pi(R^2 - r^2)}{2}$ $= 1.5708(R^2 - r^2)$	$\frac{4(R^3 - r^3)}{3\pi(R^2 - r^2)}$ $= 0.424 \frac{R^3 - r^3}{R^2 - r^2}$

Section	Area of Section, A	Distance from Neutral Axis to Extreme Fiber, y
	$dt+2a(s+n)$	$\frac{d}{2}$
	$dt+2a(s+n)$	$\frac{b}{2}$

A=area y= distance from axis to extreme fiber	Moment of Inertia I	Section Modulus $Z=\frac{I}{y}$	Radius of Gyration $k=\sqrt{\frac{I}{A}}$
 $A=bd;\ y=d$	$\frac{bd^3}{3}$	$\frac{bd^2}{3}$	$\frac{d}{\sqrt{3}}=0.577d$
 $A=bd-hk$ $y=\frac{1}{2}d$	$\frac{bd^3-hk^3}{12}$	$\frac{bd^3-hk^3}{6d}$	$\sqrt{\frac{bd^3-hk^3}{12(bd-hk)}}$ $=0.289\sqrt{\frac{bd^3-hk^3}{bd-hk}}$

Name:______________________ Date:_________________________

MFG-B15

Determine Strength of Materials For Various Applications

Self-Assessment

Answer the following questions by using the formulas from the Student Reference Sheet, which you can use during this exercise. Show all work for each question.

1. What is the direct tension exerted on a beam with a square cross-section, 1" in width, by a force of 30 pounds?

2. What is the direct compression exerted on a beam with a square cross-section, 2" in width, by a force of 40 pounds?

3. A rectangular beam is 3" x 5". A shear force of 60 pounds is exerted on it. What is the simple shear stress?

4. A shear force of 700 pounds is exerted on a circular beam 6" in diameter. What is the simple shear stress?

5. A beam has a cross-section measuring 2" x 4". If $y = 1/2d$, what is the moment of inertia for the beam?

6. What is the section modulus of the beam in Question 5?

7. A hollow, square beam has an outside width of 3"; the square cavity in it has a measurement of 2". If $y = 1/2d$, what is the moment of inertia for the beam?

8. What is the radius of gyration for the beam in Question 7?

9. What is the moment of inertia for a circular beam 6" in diameter?

10. What is the moment of inertia for a hollow circular beam 6" in outside diameter and 4" in inside diameter?

MFG-B15
Self-Assessment Answer Key

1. 30 lb/in^2

2. 10 lb/in^2

3. 4 lb/in^2

5. 24.76 lb/in^2

6. 42.76 in^4

7. 10.67

8. 5.147 in^4

9. 63.5 in^4

10. 50.96 in^4

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

Duties	Tasks												
A Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a cléan and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
	B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-C1

Subject: **Manufacturing Technology** **Time: 12 Hrs.**

Duty: **Interpret Engineering Drawings and Control Documents**
Task: Identify Basic Layout of Drawings

Objective(s):

Upon completion of this unit the student will be able to:
a. Identify types of lines within a drawing;
b. List the essential components found in the title block;
c. Locate bill of materials in a drawing; and,
d. List the components found in the revision block.

Instructional Materials:

MASTER Handouts (MFG-C1-HO) (two)
MASTER Self-Assessment
Sample drawings with matching parts
Orthographic projection box

References:

How to Read Shop Prints and Drawings, William E. Hardman, National Tooling & Machining Association, Latest Edition, "Introduction to Shop Prints"

Technical Drawing, Giesecke, Mitchell, Spencer, Hill, Dygdon, and Novak, MacMillan Publishing, Latest Edition, "Design and Working Drawings"

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Reading Drawings"

Student Preparation:

Introduction:

One of the most critical skills that a machinist develops is that of reading blueprints. This skill forms the basis of virtually all decision-making in the workplace because the blueprint is the master document governing the operation. At first look, blueprints may seem to be written in some alien language. With practice, however, the machinist

soon becomes capable of reading blueprints almost at a glance. Familiarity with the lines and conventions of drafting is all that is required.

Presentation Outline:

- I. Identify Types of Lines Within a Drawing
  - A. Break
    - 1. **Short**: a generally freehand, heavy, wavy line; indicating that the part is continuous and unchanged between the lines
      - a. Square break
      - b. Solid, round break
      - c. Hollow, round break
    - 2. **Long**: a thin line broken by zig-zags indicating that the part is continuous and unchanged between the lines
  - B. Center Lines
    - 1. A thin, broken line composed of alternating long and short lines, evenly spaced
    - 2. Uses
      - a. To show the center of a circle, arc, or part
      - b. To show that a part is bilaterally symmetrical. Used in conjunction with three parallel lines at each end
      - c. To indicate motion in conjunction with phantom lines
  - C. Cutting Plane
    - 1. A heavy, broken line whose ends, which have arrowheads pointed in the direction of the drawing, are perpendicular to the body of the line. Sometimes shown as one long and two short alternating lines.
    - 2. To indicate an imaginary cut through a piece; this line may be offset
  - D. Dimension Lines
    - 1. Thin, solid lines having arrowheads at both ends. The center is left open for dimensional specifics.
    - 2. Show the size of the piece relative to the line's direction
  - E. Extension Lines
    - 1. Thin, solid lines visibly removed from the edge to which they refer
    - 2. Used in conjunction with dimensions lines to show the sizes of objects
  - F. Hidden (Invisible) Lines
    - 1. Thin, evenly broken line
    - 2. Used to delineate any feature not visible in the particular view
  - G. Leader

        1. Thin, solid line with one arrowhead (when ending on an edge) or a dot (when ending on a surface) at one end and a bend that changes the line's direction at the other
        2. To annotate the drawing
    H. Object (Visible) Lines
        1. Very heavy, solid lines
        2. Demarcates edges, surfaces, and corners in the visible view
    I. Phantom Lines
        1. Thin line composed of one long and two short, equally spaced parts
        2. Uses
            a. Indicate alternate positions
            b. Demonstrate mating surfaces
            c. Show repetitious details
    J. Screw Threads
        1. Three methods
            a. Actual drawing (seldom used)
            b. Schematic representation
            c. Simplified representation
        2. To display threading on parts. When marked with a "B" indicates a bore or internal thread.
    K. Section
        1. Thin, solid lines, usually at a definite angle to the horizontal
        2. To indicate that the view has been cut off from the main part or that the part has been cut in two
        3. Sometimes used to identify specific materials
    J. Precedence of Lines: On occasion, lines in a drawing may be superimposed. When this occurs, the lines are shown in the following order; e.g., visible lines are shown instead of any others; etc.
        1. Visible (Object) line
        2. Hidden (Invisible) line
        3. Cutting plane line
        4. Center line
        5. When either a visible or a hidden line occludes a center line, the ends of the center line are detached from the *outside* edge of the part

II. List the Essential Components Found in the Title Block--note That Title Blocks Are Not Fully Standardized and That Their Contents May Vary from Company to Company
    A. The title block is usually found in the lower right-hand corner.
    B. Components
        1. Name and address of the manufacturer or designer
        2. *Title* or brief description of parts
        3. *Part Number* identifying the specific part

4. *Drawing Number* identifying the specific *drawing*
5. *Drawn by/Date* shows the drafter and the date of the drawing's completion
6. *Checked by/Date* shows the drawing's inspector and the date of approval
7. *Replaces* lists a part number that the new part will supersede
8. *Replaced by* lists a part that supersedes the part in the drawing. If the drawing is the most current, there will be a slash through this block.
9. *Scale* shows the proportion of the drawing to life
   a. *Full* indicates that the drawing is life-sized
   b. *Half* indicates that the drawing is one-half life size *in each dimension*
10. *Page* shows both the current page, *p*, and the total number of pages, *t*, in this format: *p of t*
11. *Tolerances* show the size limits of dimensions that are not specifically dimensioned in the drawing. These general tolerances are always secondary to tolerances listed in the drawing
12. *Heat Treatment* shows the required heat treatment and hardness specifications. If there are no specifications, then the box says NONE.
13. *Material* shows the exact material from which the part must be made
14. *Finish* indicates the general surface finish of the completed part
15. *Code Identification Number* identifies the specific manufacturer or design group. The number is provided by the Federal Government.
16. *Size* shows the physical size of the draft paper
17. The word NOTED in any block means that the information is supplied in the body of the drawing at or near the relevant item

III. Locate Bill of Materials in a Drawing: The Materials List Is Usually Located Immediately above the Title Block.

IV. List the Components Found in the Revision Block
   A. *Zone* refers to area which is to be changed. Large drawings generally have an alphanumeric coordinate system for clarity.
   B. *Revision* specifies the exact change in the part. It is identified by a letter.
   C. *Description* contains a brief description of the revision
   D. *Date* is the effective date of the revision
   E. *Apvd* abbreviates Approved. This is the identification of the inspector who approved the changes.

Practical Application:

The student will be able to identify the basic components of the title block and other notation blocks on a blueprint, as well as recognizing the various lines and their applications.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-C2) dealing with the different types of drawings used in the machine shop.

MFG-C1-HO1
Identify Basic Layout of Drawings
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify types of lines within a drawing;
b. List the essential components found in the title block;
c. Locate bill of materials in a drawing; and,
d. List the components found in the revision block.

Module Outline:

I. Identify Types of Lines Within a Drawing
  - A. Break
    - 1. **Short**: a generally freehand, heavy, wavy line; indicating that the part is continuous and unchanged between the lines
      - a. Square break
      - b. Solid, round break
      - c. Hollow, round break
    - 2. **Long**: a thin line broken by zig-zags indicating that the part is continuous and unchanged between the lines
  - B. Center Lines
    - 1. A thin, broken line composed of alternating long and short lines, evenly spaced
    - 2. Uses
      - a. To show the center of a circle, arc, or part
      - b. To show that a part is bilaterally symmetrical. Used in conjunction with three parallel lines at each end
      - c. To indicate motion in conjunction with phantom lines
  - C. Cutting Plane
    - 1. A heavy, broken line whose ends, which have arrowheads pointed in the direction of the drawing, are perpendicular to the body of the line. Sometimes shown as one long and two short alternating lines.
    - 2. To indicate an imaginary cut through a piece; this line may be offset
  - D. Dimension Lines
    - 1. Thin, solid lines having arrowheads at both ends. The center is left open for dimensional specifics.
    - 2. Show the size of the piece relative to the line's direction
  - E. Extension Lines

1. Thin, solid lines visibly removed from the edge to which they refer
2. Used in conjunction with dimensions lines to show the sizes of objects

F. Hidden (Invisible) Lines
   1. Thin, evenly broken line
   2. Used to delineate any feature not visible in the particular view

G. Leader
   1. Thin, solid line with one arrowhead (when ending on an edge) or a dot (when ending on a surface) at one end and a bend that changes the line's direction at the other
   2. To annotate the drawing

H. Object (Visible) Lines
   1. Very heavy, solid lines
   2. Demarcates edges, surfaces, and corners in the visible view

I. Phantom Lines
   1. Thin line composed of one long and two short, equally spaced parts
   2. Uses
      a. Indicate alternate positions
      b. Demonstrate mating surfaces
      c. Show repetitious details

J. Screw Threads
   1. Three methods
      a. Actual drawing (seldom used)
      b. Schematic representation
      c. Simplified representation
   2. To display threading on parts. When marked with a "B" indicates a bore or internal thread.

K. Section
   1. Thin, solid lines, usually at a definite angle to the horizontal
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   3. Sometimes used to identify specific materials

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   2. Hidden (Invisible) line
   3. Cutting plane line
   4. Center line
   5. When either a visible or a hidden line occludes a center line, the ends of the center line are detached from the *outside* edge of the part

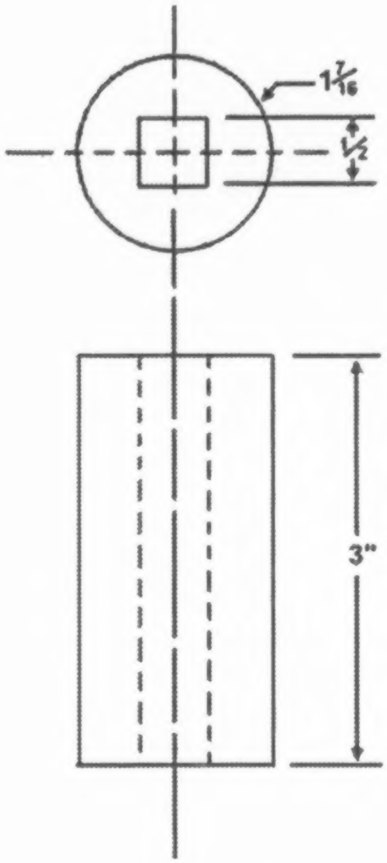
II. List the Essential Components Found in the Title Block--note That Title Blocks Are Not Fully Standardized and That Their Contents May Vary from Company to Company
    A. The title block is usually found in the lower right-hand corner.
    B. Components
        1. Name and address of the manufacturer or designer
        2. *Title* or brief description of parts
        3. *Part Number* identifying the specific part
        4. *Drawing Number* identifying the specific *drawing*
        5. *Drawn by/Date* shows the drafter and the date of the drawing's completion
        6. *Checked by/Date* shows the drawing's inspector and the date of approval
        7. *Replaces* lists a part number that the new part will supersede
        8. *Replaced by* lists a part that supersedes the part in the drawing. If the drawing is the most current, there will be a slash through this block.
        9. *Scale* shows the proportion of the drawing to life
            a. *Full* indicates that the drawing is life-sized
            b. *Half* indicates that the drawing is one-half life size *in each dimension*
        10. *Page* shows both the current page, *p*, and the total number of pages, *t*, in this format: *p of t*
        11. *Tolerances* show the size limits of dimensions that are not specifically dimensioned in the drawing. These general tolerances are always secondary to tolerances listed in the drawing
        12. *Heat Treatment* shows the required heat treatment and hardness specifications. If there are no specifications, then the box says NONE.
        13. *Material* shows the exact material from which the part must be made
        14. *Finish* indicates the general surface finish of the completed part
        15. *Code Identification Number* identifies the specific manufacturer or design group. The number is provided by the Federal Government.
        16. *Size* shows the physical size of the draft paper
        17. The word NOTED in any block means that the information is supplied in the body of the drawing at or near the relevant item

III. Locate Bill of Materials in a Drawing: The Materials List Is Usually Located Immediately above the Title Block.

IV. List the Components Found in the Revision Block
    A. *Zone* refers to area which is to be changed. Large drawings generally have an alphanumeric coordinate system for clarity.

B. *Revision* specifies the exact change in the part. It is identified by a letter.
C. *Description* contains a brief description of the revision
D. *Date* is the effective date of the revision
E. *Apvd* abbreviates Approved. This is the identification of the inspector who approved the changes.

MFG-C1-HO2
Identify Basic Layout of Drawings
Attachment 2: **MASTER** Handout



SQUARE HOLE IN A ROUND PEG			
PART NO.	1010106	DRAWING NO.	A1576B
CHECKED BY	R. van Rijn	10/31/97	
REPLACES	A. Rand	11/14/97	
SCALE	1010071	REPLACED BY	——
TOLERANCES	±1/64	PAGE	1 of 1
MATERIAL	Plutonium	FINISH	RMS

Name____________________________ Date_______________

MFG-C1
Identify Basic Layout of Drawings
Self-Assessment

Identify the following lines:

1. Place the proper letter in front of each of the descriptions that best describe the line.

   (A). BREAK LINE SHORT
   (B). BREAK LINE LONG
   (C). CENTER LINES
   (D). CUTTING PLANE LINES
   (E). DIMENSION LINES
   (F). EXTENSION LINES
   (G). HIDDEN LINES (INVISIBLE)
   (H). LEADER LINES
   (I). OBJECT LINES (VISIBLE)
   (J). PHANTOM LINES
   (K). SECTION LINES

( ). Thin, solid lines, usually at a definite angle to the horizontal.

( ). Thin line composed of one long and two short, equally spaced, parts.

( ). Very heavy, solid lines.

( ). A heavy, broken line whose ends, which have arrowheads pointed in the direction of the drawing, are perpendicular to the body of the line. Sometimes shown as one long and two short alternating lines.

( ). Thin, solid lines having arrowheads at both ends. The center is left open.

( ). Thin, solid lines visibly removed from the edge to which they refer.

( ). Thin, even broken line.

( ). Thin, solid line with one arrowhead (when ending on an edge) or a dot (when ending on a surface) at one end and a bend that changes the line's direction at the other.

MFG-C1
Identify Basic Layout of Drawings
Self-Assessment

1. K.

   J.

   I.

   D.

   E.

   F.

   G.

   H.

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-C2

Subject: **Manufacturing Technology** **Time: 4 Hrs.**

Duty: **Interpret Engineering Drawings and Control Documents**
Task: Identify Basic Types of Drawings

Objective(s):

Upon completion of this unit the student will be able to:
a. Identify orthographic views;
b. Identify positions of views (top, front, side, and auxiliary);
c. Visualize one or more views from a given view;
d. Identify isometric views;
e. Identify exploded isometric drawings; and,
f. Identify assembly drawings.

Instructional Materials:

MASTER Handout (MFG-C2-HO)
MASTER Self-Assessment
Several prints showing each of the above views
Parts corresponding to the drawings used

References:

How to Read Shop Prints and Drawings, William E. Hardman, National Tooling & Machining Association, Latest Edition, "Introduction to Shop Prints & Lines and Their Uses in Orthographic Projections"
Technical Drawing, Giesecke, Mitchell, Spencer, Hill, Dygdon, and Novak, MacMillan Publishing, Latest Edition, "Axonometric Projections"
Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Reading Drawings"
Machinery's Handbook, Industrial Press, Latest Edition

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-C1 "Identify Basic Layout of Drawings"

Introduction:

Blueprints come in many forms. Although most of them are orthographic, a large number of them are done in other perspectives since the orthographic view is not always the best-suited to the manufacture of a specific part. Other projections aid in visualizing the final part, and allow the technician to see the workpiece before it is actually made.

Presentation Outline:

I. Identify Orthographic Views
    A. Characteristics of orthography: all views perpendicular to the viewer; no vanishing points
    B. Review the *projection planes*
II. Identify Positions of Views
    A. Top
    B. Front
    C. Side
    D. Auxiliary
III. Visualize One or More Views from a Given Angle
IV. Identify Isometric Views: All Angles at the Reference Origin Are 120°
V. Identify Exploded Isometric Drawings
VI. Identify Assembly Drawings

Practical Application:

Students shall be able to identify all views and projections covered in this module and to discuss their purposes and uses.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-C3) dealing with blueprint notes and dimensions.

MFG-C2-HO
Identify Basic Types of Drawings
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify orthographic views;
b. Identify positions of views (top, front, side, and auxiliary);
c. Visualize one or more views from a given view;
d. Identify isometric views;
e. Identify exploded isometric drawings; and,
f. Identify assembly drawings.

Module Outline:

I. Identify Orthographic Views
    A. Characteristics of orthography: all views perpendicular to the viewer; no vanishing points
    B. Review the *projection planes*
II. Identify Positions of Views
    A. Top
    B. Front
    C. Side
    D. Auxiliary
III. Visualize One or More Views from a Given Angle
IV. Identify Isometric Views: All Angles at the Reference Origin Are 120°
V. Identify Exploded Isometric Drawings
VI. Identify Assembly Drawings

Name____________________________ Date_______________

MFG-C2
Identify Basic Types of Drawings
Self-Assessment

Circle the letter preceding the correct answer.

1. What is the main purpose of isometric drawings?
   - A. To render an object in three dimensions
   - B. To show the relationship of the parts more clearly
   - C. To demonstrate the finish of the part
   - D. To relieve the stress on drafters
   - E. None of the above answers is correct.

2. What is the main purpose of exploded isometric drawings?
   - A. To render an object in three dimensions
   - B. To show the relationship of the parts more clearly
   - C. To demonstrate the finish of the part
   - D. To relieve the stress on drafters
   - E. None of the above answers is correct.

3. Which of the following is characteristic of *orthographic* projection?
   - A. All views are perpendicular to the drafter
   - B. All angles are 120° around a central axis
   - C. Two vanishing points
   - D. One axis parallel to the plane of the drawing
   - E. None of the above answers is correct.

4. Which of the following is characteristic of *isometric* projection?
   - A. All views are perpendicular to the drafter
   - B. All angles are 120° around a central axis
   - C. Two vanishing points
   - D. One axis parallel to the plane of the drawing
   - E. None of the above answers is correct.

5. Which of the following is characteristic of *oblique* projection?
   - A. All views are perpendicular to the drafter
   - B. All angles are 120° around a central axis
   - C. Two vanishing points
   - D. One axis parallel to the plane of the drawing
   - E. None of the above answers is correct.

6. In the United States, most orthographic drawings are _____ angle projections.
   A. First
   B. Second
   C. Third
   D. Fourth
   E. None of the above answers is correct.

7. Europeans usually use the _____ angle projection.
   A. First
   B. Second
   C. Third
   D. Fourth
   E. None of the above answers is correct.

8. First angle projections are _____, relative to the viewer.
   A. Upside-down
   B. Mirror-imaged
   C. Both A and B are correct.
   D. None of the above answers is correct.

9. The international projection symbols show:
   A. Which angle of projection is used.
   B. How many projections are in the drawing.
   C. Whether a drawing is isometric or oblique.
   D. The nation of the drawing's origin.
   E. None of the above answers is correct.

10. An auxiliary view shows:
   A. Inclined surfaces that cannot be clearly shown on a principal view.
   B. The position and relationship of the parts in an assembly.
   C. The complete depth of the part, with 45° vanishing angles.
   D. All of the above answers are correct.
   E. None of the above answers is correct.

MFG-C2
Identify Basic Types of Drawings
Self-Assessment Answer Key

1. A
2. B
3. A
4. B
5. D
6. C
7. A
8. C
9. A
10. A

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-C3

Subject: **Manufacturing Technology** **Time: 12 Hrs.**

Duty: **Interpret Engineering Drawings and Control Documents**
Task: Review Blueprint Notes and Dimensions

Objective(s):

Upon completion of this unit the student will be able to:
a. Explain basic blueprint terminology;
b. Identify the types of dimensions;
c. Identify general note symbols;
d. Locate notes on a print;
e. Interpret commonly used abbreviations and terminology;
f. Determine tolerances associated with dimensions on a drawing;
g. Determine the tolerance for a reference dimension;
h. Determine the surface finish for a given part; and,
i. List the essential components found in the general drawing notes.

Instructional Materials:

MASTER Handout (MFG-C3-HO)
MASTER Self-Assessment
Several drawings with various projects
Parts corresponding to the selected drawings

References:

How to Read Shop Prints and Drawings, William E. Hardman, National Tooling & Machining Association, Latest Edition, "Introduction to Shop Prints & Lines and Their Uses in Orthographic Projections"
Technical Drawing, Giesecke, Mitchell, Spencer, Hill, Dygdon, and Novak, MacMillan Publishing, Latest Edition, "Axonometric Projections"
Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Reading Drawings"

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-C1 "Identify Basic Layout of Drawings"
MFG-C2 "Identify Basic Types of Drawings"

Introduction:

Of all the skills necessary to a successful career as a machinist, one of the most basic and most important is the ability to read and interpret blueprints and other designs. Without such knowledge, the machinist is completely lost, unable to produce even the simplest parts correctly. The correct interpretation of prints, regardless of whether they are called blueprints, white prints, or something else; requires more than knowledge of lines. The machinist must also thoroughly comprehend the written components of the print.

Presentation Outline:

I. Explain Basic Blueprint Terminology
  A. Print Definitions
    1. **Print**: an exact copy of an engineering drawing
    2. **Engineering drawing**: the original design of anything as drawn by the drafter
  B. Print Parts and Terms
    1. **Title Block**: an area for the controlling information of a document, usually set apart in the lower right-hand corner
    2. **Print Body**: the actual drawing of the item, normally consisting of several views
    3. **View**: the angle of observation of the artist, usually the top, front, and right side of the item
    4. Projections
      a. **Orthographic**: all views are perpendicular to the drafter's field of vision, lacks vanishing points
      b. **Isometric**: built around a central point whose radiant axes are equally spaced at 120°
      c. Other **Axonometric** Views: briefly discuss other views, such as diametric
    5. Angles of Projection
      a. **First Angle Projections** are usually European and SI
      b. **Third Angle Projections** are North American and either SI or SAE

II. Identify the Types of Dimensions
  A. Physical Dimensions
    1. **Linear** dimensions show height, width, and length as direction along a straight line
    2. **Angular** dimensions display the sizes of angular features
      a. **Angle of the arc** is size of the actual angle, usually in degrees

        b. **Length of the arc** measures the size of a rounded feature along the rounded edge. This is usually a reference dimension.
        c. **Length of the chord** is the direct distance between the end points of the arc
    3. **Radial dimensions** display the size of radii (the plural of radius). Discuss *shortened radii* and *true* and *spherical radii.*
    4. **Coordinate dimensions** all begin at a particular point known as a *datum point*
        a. **Rectangular** coordinate dimensions start at some arbitrary datum point 0,0 and are noted in a Cartesian plane
        b. **Polar** coordinate dimensions start at some arbitrary datum point 0,0 and are noted in lengths of radii and angles of arcs
    5. **Tabular** dimensions establish a table of references with a key that is tied to a drawing. This method reduces confusion by eliminating clutter in the body of the drawing.
  B. Engineering Dimensions Conventions
    1. Usually placed in the area that best shows the feature
    2. Use of *dimension lines, leader lines,* and *extension lines*
    3. **Working** dimensions are those used to control the size of the part
    4. **Reference** dimensions are those used to contribute useful, but not essential, information to the machinist
    5. **In-process** dimensions show the size of the part after a specific machine process, such as milling, but not the final size of the part. These dimensions are noted as such.
    6. **Scale** shows the size of the drawing relative to the size of the part
    7. **Tolerances** may be in the title block or noted in the drawing
  C. Placement of Dimensions
    1. **Chaining** shows the relationships between the details of features in a series; sometimes called *incremental dimensioning*
    2. **Datum** dimensioning shows the details of features in relation to an arbitrary datum point 0,0; also called *absolute* or *base-line* dimensioning
    3. **Direct** dimensioning shows the relationship between two features where that relationship is completely independent of the rest of the part
III. Identify General Note Symbols
IV. Identify item number symbols
  A. Angular symbols
    1. ° indicates degrees

        - 2. ' indicates minutes
        - 3. " indicates seconds
        - 4. D or DIA indicates diameter
        - 5. R or RAD indicates radius
    - B. Linear symbols
        - 1. ' indicates feet
        - 2. " indicates inches
        - 3. Metric linear abbreviations are not symbolic; they are alphabetical abbreviations. Discuss mm, cm, etc.
- V. Locate Notes on a Print
    - A. Dimensional: give specific values to sizes. Discuss conventions on *dual unit dimensioning*.
    - B. Process
    - C. Detail
    - D. Single-view
    - E. Thickness
- VI. Interpret Commonly Used Abbreviations and Terminology
- VII. Determine Tolerances Associated with Dimensions on a Drawing
    - A. Discuss the differences in *standard* or *customary* tolerances and *specific* tolerances
    - B. Discuss linear tolerance and radial tolerance
- VIII. Determine the Tolerance for a Reference Dimension
- IX. Determine the Surface Finish for a Given Part
    - A. Definitions
        - 1. **Roughness**: the fine, irregular ridges/troughs caused by the finishing machine
        - 2. **Waviness**: the large, irregular ridges/troughs caused by the finishing machine. Roughness rides the surface of waviness.
        - 3. **Lay**: the predominant direction of the marks in the surface finish
        - 4. **Waviness Spacing:** the distance between the peaks of two adjacent ridges in the waviness
        - 5. **Waviness Height:** measured within a single waviness spacing, specifies the distance between the higher peak and the bottom of the trough
        - 6. **Roughness Spacing:** similar to waviness spacing, the distance between two adjacent peaks in the waviness
        - 7. **Roughness Sampling Length:** the length of an arbitrary sample of the roughness, used to determine the roughness average
        - 8. **Roughness Average:** the mathematical average of the roughness of a surface within a *roughness sampling length*, measured from a center line and measured in micro inches
        - 9. Lay Symbols:

            - a. **Angular lay:** lay runs in two mutually perpendicular directions that are set at an angle that is oblique to the reference line
            - b. **Circular lay:** lay is basically circular around the center of the surface
            - c. **Multi-directional lay:** lay has no predominant direction
            - d. **Parallel lay:** lay is parallel to the reference line
            - e. **Particulate lay:** lay has no direction, is protuberant, or particulate
            - f. **Perpendicular lay:** lay is perpendicular to the reference line
            - g. **Radial lay:** lay is basically radial through the center of the surface
    - B. Basic and variant surface texture symbols
        - 1. Basic checkmark with roughness indicators--maximum only and maximum/minimum values
        - 2. Finish removal triangular checkmark with removal value
        - 3. Already finished checkmark with tangential circle
- X. List the Essential Components Found in the General Drawing Notes

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Practical Application:

All students should be able to look at a simple blueprint and identify all its lines.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-C4) dealing with the purpose of each type of drawing.

MFG-C3-HO
Review Blueprint Notes and Dimensions
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Explain basic blueprint terminology;
- b. Identify the types of dimensions;
- c. Identify general note symbols;
- d. Locate notes on a print;
- e. Interpret commonly used abbreviations and terminology;
- f. Determine tolerances associated with dimensions on a drawing;
- g. Determine the tolerance for a reference dimension;
- h. Determine the surface finish for a given part; and,
- i. List the essential components found in the general drawing notes.

Module Outline:

- I. Explain Basic Blueprint Terminology
  - A. Print Definitions
    - 1. **Print**: an exact copy of an engineering drawing
    - 2. **Engineering drawing:** the original design of anything as drawn by the drafter
  - B. Print Parts and Terms
    - 1. **Title Block**: an area for the controlling information of a document, usually set apart in the lower right-hand corner
    - 2. **Print Body**: the actual drawing of the item, normally consisting of several views
    - 3. **View**: the angle of observation of the artist, usually the top, front, and right side of the item
    - 4. Projections
      - a. **Orthographic**: all views are perpendicular to the drafter's field of vision, lacks vanishing points
      - b. **Isometric**: built around a central point whose radiant axes are equally spaced at 120°
      - c. Other **Axonometric** Views: briefly discuss other views, such as diametric
    - 5. Angles of Projection
      - a. **First Angle Projections** are usually European and SI
      - b. **Third Angle Projections** are North American and either SI or SAE
- II. Identify the Types of Dimensions
  - A. Physical Dimensions

1. **Linear** dimensions show height, width, and length as direction along a straight line
2. **Angular** dimensions display the sizes of angular features
    a. **Angle of the arc** is size of the actual angle, usually in degrees
    b. **Length of the arc** measures the size of a rounded feature along the rounded edge. This is usually a reference dimension.
    c. **Length of the chord** is the direct distance between the end points of the arc
3. **Radial dimensions** display the size of radii (the plural of radius). Discuss *shortened radii* and *true* and *spherical radii.*
4. **Coordinate dimensions** all begin at a particular point known as a *datum point*
    a. **Rectangular** coordinate dimensions start at some arbitrary datum point 0,0 and are noted in a Cartesian plane
    b. **Polar** coordinate dimensions start at some arbitrary datum point 0,0 and are noted in lengths of radii and angles of arcs
5. **Tabular** dimensions establish a table of references with a key that is tied to a drawing. This method reduces confusion by eliminating clutter in the body of the drawing.

B. Engineering Dimensions Conventions
1. Usually placed in the area that best shows the feature
2. Use of *dimension lines, leader lines,* and *extension lines*
3. **Working** dimensions are those used to control the size of the part
4. **Reference** dimensions are those used to contribute useful, but not essential, information to the machinist
5. **In-process** dimensions show the size of the part after a specific machine process, such as milling, but not the final size of the part. These dimensions are noted as such.
6. **Scale** shows the size of the drawing relative to the size of the part
7. **Tolerances** may be in the title block or noted in the drawing

C. Placement of Dimensions
1. **Chaining** shows the relationships between the details of features in a series; sometimes called *incremental dimensioning*
2. **Datum** dimensioning shows the details of features in relation to an arbitrary datum point 0,0; also called *absolute* or *base-line* dimensioning

3. **Direct dimensioning shows the relationship between two features where that relationship is completely independent of the rest of the part**

III. Identify General Note Symbols

IV. Identify item number symbols

A. Angular symbols

1. ° indicates degrees
2. ' indicates minutes
3. " indicates seconds
4. D or DIA indicates diameter
5. R or RAD indicates radius

B. Linear symbols

1. ' indicates feet
2. " indicates inches
3. Metric linear abbreviations are not symbolic; they are alphabetical abbreviations. Discuss mm, cm, etc.

V. Locate Notes on a Print

A. Dimensional: give specific values to sizes. Discuss conventions on *dual unit dimensioning.*

B. Process

C. Detail

D. Single-view

E. Thickness

VI. Interpret Commonly Used Abbreviations and Terminology

VII. Determine Tolerances Associated with Dimensions on a Drawing

A. Discuss the differences in *standard* or *customary* tolerances and *specific* tolerances

B. Discuss linear tolerance and radial tolerance

VIII. Determine the Tolerance for a Reference Dimension

IX. Determine the Surface Finish for a Given Part

A. Definitions

1. **Roughness**: the fine, irregular ridges/troughs caused by the finishing machine
2. **Waviness**: the large, irregular ridges/troughs caused by the finishing machine. Roughness rides the surface of waviness.
3. **Lay**: the predominant direction of the marks in the surface finish
4. **Waviness Spacing:** the distance between the peaks of two adjacent ridges in the waviness
5. **Waviness Height:** measured within a single waviness spacing, specifies the distance between the higher peak and the bottom of the trough
6. **Roughness Spacing:** similar to waviness spacing, the distance between two adjacent peaks in the waviness

7. **Roughness Sampling Length:** the length of an arbitrary sample of the roughness, used to determine the roughness average
8. **Roughness Average:** the mathematical average of the roughness of a surface within a *roughness sampling length*, measured from a center line and measured in micro inches
9. Lay Symbols:
   a. **Angular lay:** lay runs in two mutually perpendicular directions that are set at an angle that is oblique to the reference line
   b. **Circular lay:** lay is basically circular around the center of the surface
   c. **Multi-directional lay:** lay has no predominant direction
   d. **Parallel lay:** lay is parallel to the reference line
   e. **Particulate lay:** lay has no direction, is protuberant, or particulate
   f. **Perpendicular lay:** lay is perpendicular to the reference line
   g. **Radial lay:** lay is basically radial through the center of the surface

B. Basic and variant surface texture symbols
   1. Basic checkmark with roughness indicators--maximum only and maximum/minimum values
   2. Finish removal triangular checkmark with removal value
   3. Already finished checkmark with tangential circle

X. List the Essential Components Found in the General Drawing Notes

Name____________________________ Date________________

MFG-C3
Review Blueprint Notes and Dimensions
Self-Assessment

Circle the letter preceding the correct answer.

1. ___ dimensions show length, width, and height as straight lines.
   A. Angular
   B. Linear
   C. Radial
   D. All of the above answers are correct.
   E. None of the above answers is correct.

2. What is meant by *circular lay?*
   A. The pattern of the finish is not parallel to the sides of the piece.
   B. The pattern of the finish is not parallel to anything.
   C. The pattern of the finish is roughly circular.
   D. All of the above answers are correct.
   E. None of the above answers is correct.

3. In ___ projection, all views are perpendicular to the viewer.
   A. Isometric
   B. Orthographic
   C. Oblique
   D. All of the above answers are correct.
   E. None of the above answers is correct.

4. In ___ projection, all views are centered on a particular point with 120° angles.
   A. Isometric
   B. Orthographic
   C. Oblique
   D. All of the above answers are correct.
   E. None of the above answers is correct.

5. The fine, irregular ridges/troughs caused by the finishing machine are called:
   A. Roughness
   B. Waviness
   C. Lay
   D. All of the above answers are correct.
   E. None of the above answers is correct.

6. ___ rides the surface of ___.
   A. Waviness . . . lay
   B. Waviness . . . roughness
   C. Lay . . . waviness
   D. Roughness . . . waviness
   E. None of the above answers is correct.

7. The angle of the arc is:
   A. The size of the actual angle, usually in degrees.
   B. The size of a rounded feature along the rounded edge, usually a reference dimension.
   C. The direct distance between the end points of the arc.
   D. All of the above answers are correct.
   E. None of the above answers is correct.

8. **Chaining** shows the:
   A. Relationships between the details of features in a series.
   B. Details of features in relation to an arbitrary datum point 0,0.
   C. Relationship between two features where that relationship is completely independent of the rest of the part.
   D. All of the above answers are correct.
   E. None of the above answers is correct.

9. **Datum dimensioning** shows the:
   A. Relationships between the details of features in a series.
   B. Details of features in relation to an arbitrary datum point 0,0.
   C. Relationship between two features where that relationship is completely independent of the rest of the part.
   D. All of the above answers are correct.
   E. None of the above answers is correct.

10. In angular dimensioning, the apostrophe (') indicates ___, while the quotation mark (") indicates ___.
   A. Minutes . . . seconds
   B. Seconds . . . minutes
   C. Feet . . . inches
   D. Inches . . . feet
   E. None of the above answers is correct.

MFG-C3
Review Blueprint Notes and Dimensions
Self-Assessment Answer Key

1. B

2. C

3. B

4. A

5. A

6. D

7. A

8. A

9. B

10. A

MFG-C4

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-C4

Subject: **Manufacturing Technology** **Time: 8 Hrs.**

Duty: **Interpret Engineering Drawings and Control Documents**
Task: List the Purpose of Each Type of Drawing

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify the purpose of orthographic (3 views) drawings;
b. Identify the purpose of isometric drawing;
c. Identify the purpose of exploded isometric drawing; and,
d. Identify the purpose of assembly drawings.

Instructional Materials:

MASTER Handout (MFG-C4-HO)
MASTER Self-Assessment
Several engineering drawings, with at least one isometric and at least one exploded view
Several assembly drawings

References:

How to Read Shop Prints and Drawings, William E. Hardman, National Tooling & Machining Association, Latest Edition, "Introduction to Shop Prints & Lines and Their Uses in Orthographic Projections"
Technical Drawing, Giesecke, Mitchell, Spencer, Hill, Dygdon, and Novak, MacMillan Publishing, Latest Edition, "Anonometric Projections"
Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Reading Drawings"

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-C1 "Identify Basic Layout of Drawings"
MFG-C2 "Identify Basic Types of Drawings"
MFG-C3 "Review Blueprint Notes and Dimensions"

Introduction:

Learning the various forms of drawings is the key to a full understanding of blueprints and other engineering drawings.

Presentation Outline:

NB: The Self-Assessment for this module is greatly dependent on the engineering drawings presented. Therefore, the instructor must complete the questions for the Self-Assessment. The editors strongly recommend a minimum of twenty questions for this module.

- I. Identify the Purpose of Orthographic Views
  - A. Any orthographic drawing must have a minimum of two views in order to show an object completely.
  - B. The top view may be referred to as the plan view. The front or side views may be referred to as the elevations views.
- II. Identify Positions of Views (Top, Front, Side, and Auxiliary)
  - A. Top, is usually to the left and at the top of the print when viewing a single object, and represents the objects top if you were looking down at it.
  - B. Front is directly below the top view, and on the same center line as the top. The front does not necessarily mean the actual front of the object.
  - C. Side or sometimes referred as the right side is normally the right side of the front view and is on the same center lines as well as the same elevation.
- III. Visualize One or More Views from a Given View
  - A. In any given view the student can visualize more then one side of a object. The object can be shown in one of many positions.
- IV. Identify Isometric Views
  - A. Any object can be drawn from four different directions isometrically, but there is usually one view that best shows the object.
  - B. When using isometrics the student should be familiar with the isometric axes, and the term preferred north and alternate north.
  - C. In the isometric format, the lines of the object remain parallel and the object is drawn about the three isometric axes that are 120° degrees apart which is at 30° from the plane of the drawing.
  - D. Isometrics distort dimensions; therefore, you cannot draw isometrics to scale.
- V. Identify Exploded Isometric Drawings
  - A. An *exploded drawing* is a picture of an assembly of several parts drawn isometrically to show the proper steps in assembling a unit.
- VI. Identify Assembly Drawings

A. *Assembly drawings* are drawings in which the various parts of an object are shown in their relative positions in the completed unit.

B. Assembly drawings are also used:
   1. To illustrate the proper working relationships of the mating parts of an object and the function of each.
   2. To show a general idea of how the finished product should look.
   3. To assist in securing overall dimensions and center lines in assembly.
   4. To give the machinist data needed to design the smaller units of a larger object
   5. To provide illustrations which may be used for maintenance manuals or other purposes.

Practical Application:

Students will be able to readily identify all covered views and to discuss the purposes of each. Students will also select the proper parts from an array to fulfill the requirements of the assembly drawing.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-C5) dealing with the verification of drawing elements.

MFG-C4-HO
List the Purpose of Each Type of Drawing
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Identify the purpose of orthographic (3 views) drawings;
- b. Identify the purpose of isometric drawing;
- c. Identify the purpose of exploded isometric drawing; and,
- d. Identify the purpose of assembly drawings.

Module Outline:

NB: The Self-Assessment for this module is greatly dependent on the engineering drawings presented. Therefore, the instructor must complete the questions for the Self-Assessment. The editors strongly recommend a minimum of twenty questions for this module.

- I. Identify the Purpose of Orthographic Views
  - A. Any orthographic drawing must have a minimum of two views in order to show an object completely.
  - B. The top view may be referred to as the plan view. The front or side views may be referred to as the elevations views.
- II. Identify Positions of Views (Top, Front, Side, and Auxiliary)
  - A. Top, is usually to the left and at the top of the print when viewing a single object, and represents the objects top if you were looking down at it.
  - B. Front is directly below the top view, and on the same center line as the top. The front does not necessarily mean the actual front of the object.
  - C. Side or sometimes referred as the right side is normally the right side of the front view and is on the same center lines as well as the same elevation.
- III. Visualize One or More Views from a Given View
  - A. In any given view the student can visualize more then one side of a object. The object can be shown in one of many positions.
- IV. Identify Isometric Views
  - A. Any object can be drawn from four different directions isometrically, but there is usually one view that best shows the object.
  - B. When using isometrics the student should be familiar with the isometric axes, and the term preferred north and alternate north.
  - C. In the isometric format, the lines of the object remain parallel and the object is drawn about the three isometric axes that are 120° degrees apart which is at 30° from the plane of the drawing.

- D. Isometrics distort dimensions; therefore, you cannot draw isometrics to scale.

V. Identify Exploded Isometric Drawings

- A. An *exploded drawing* is a picture of an assembly of several parts drawn isometrically to show the proper steps in assembling a unit.

VI. Identify Assembly Drawings

- A. *Assembly drawings* are drawings in which the various parts of an object are shown in their relative positions in the completed unit.
- B. Assembly drawings are also used:
  1. To illustrate the proper working relationships of the mating parts of an object and the function of each.
  2. To show a general idea of how the finished product should look.
  3. To assist in securing overall dimensions and center lines in assembly.
  4. To give the machinist data needed to design the smaller units of a larger object
  5. To provide illustrations which may be used for maintenance manuals or other purposes.

Name______________________________ Date________________

MFG-C4
List the Purpose of Each Type of Drawing
Self-Assessment

Circle the letter preceding the correct answer.

1. In a orthographic drawing, what are the minimum views used that could show an object completely?
   A. 1
   B. 2
   C. 3
   D. The minimum number of views depends on the number of faces the object has.
   E. None of the above answers is correct.

2. In a orthographic drawing, what is the normal number of views used?
   A. 1
   B. 2
   C. 3
   D. Orthographic drawings have no "normal" number of views.
   E. None of the above answers is correct.

3. In an isometric drawing, the object is drawn at what angle?
   A. 45°
   B. 30°
   C. 90°
   D. Isometric drawings are rendered perpendicular to the plane of view.
   E. None of the above answers is correct.

4. Assembly drawings are used to:
   A. To show a general idea of how the finished product should look.
   B. To assist in securing overall dimensions and center lines in assembly.
   C. To give the machinist data needed to design the smaller units of a larger object
   D. All of the above are legitimate uses of assembly drawings.
   E. None of the above answers is correct.

MFG-C4
List the Purpose of Each Type of Drawing
Self-Assessment Answer Key

1. B

2. C

3. B

4. D

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-C5

Subject: **Manufacturing Technology** **Time: 2 Hrs.**

Duty: **Interpret Engineering Drawings and Control Documents**
Task: Verify Drawing Elements

Objective(s):

Upon completion of this unit the student will be able to:
a. Recognize out-of-date blueprints;
b. Check for revisions; and,
c. Determine the scale of the view or section.

Instructional Materials:

MASTER Handout (MFG-C5-HO)
MASTER Self-Assessment
Set of **obsolete** blueprints
Set of **current** blueprints for comparison

References:

How to Read Shop Prints and Drawings, William E. Hardman, National Tooling & Machining Association, Latest Edition, "Introduction to Shop Prints"
Technical Drawing, Giesecke, Mitchell, Spencer, Hill, Dygdon, and Novak, MacMillan Publishing, Latest Edition, "Design and Working Drawings"
Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Reading Drawings"

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-C1 "Identify Basic Layout of Drawings"
MFG-C2 "Identify Basic Types of Drawings"
MFG-C3 "Review Blueprint Notes and Dimensions"
MFG-C4 "List the Purpose of Each Type of Drawing"

Introduction:

As with all other aspects of today's society, blueprints are constantly changing. New models replace old models on a daily basis; old models seem to be updated hourly. Due to this ever-raging storm of change, all machinists must be familiar with those signs which announce to them that their particular blueprints may not be the most current design. Failure to recognize obsolete blueprints can result in lost work, scrap, and lost profits to the industry.

Presentation Outline:

- I. Recognize Out-of-Date Blueprints
  - A. Check title block for date of completion (*Drawn By*)
  - B. Check title block for date of certification (*Checked By*)
  - C. Check title block for discontinuation (*Replaced By*)
  - D. Check title block for what the new drawing replaces (*Replaces*)
- II. Check for Revisions
  - A. Revisions are usually listed in a separate block
  - B. Revision (change) lists usually contain the following blocks:
    - 1. **Zone** (on large drawing sheets) shows the area of the revision, using an alphanumeric Cartesian plane
    - 2. **Revision** shows the exact location of the revision, usually by an alphabetic indicator
    - 3. **Description** gives a brief description of the change, such as a size change, a new part, or an angular cut difference
    - 4. **Date** indicates the date the revision was approved and became effective
    - 5. **Approved By** usually abbreviated, this block shows the person who approved the individual change
- III. Determine the Scale of the View or Section
  - A. Check the title block for the overall scale of the drawing
  - B. Each detail view must be checked for scale
  - C. Notes on scale
    - 1. **Full** or **1:1**--the part is drawn to its actual size
    - 2. **Half** or **1/2:1**--the part is drawn to one-half its actual size
    - 3. Any other scale would be distinctly noted
- IV. The Word *Noted* in Any Block Indicates That the Desired Information Can Be Found Written Somewhere on the Drawing, Usually Very Close to the Area to Which it Applies

Practical Application:

The student should be able to quickly recognize obsolete blueprints.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-C6) dealing with geometric dimensioning and tolerancing (GD&T).

MFG-C5-HO
Verify Drawing Elements
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Recognize out-of-date blueprints;
- b. Check for revisions; and,
- c. Determine the scale of the view or section.

Module Outline:

- I. Recognize Out-of-Date Blueprints
    - A. Check title block for date of completion (*Drawn By*)
    - B. Check title block for date of certification (*Checked By*)
    - C. Check title block for discontinuation (*Replaced By*)
    - D. Check title block for what the new drawing replaces (*Replaces*)
- II. Check for Revisions
    - A. Revisions are usually listed in a separate block
    - B. Revision (change) lists usually contain the following blocks:
        - 1. **Zone** (on large drawing sheets) shows the area of the revision, using an alphanumeric Cartesian plane
        - 2. **Revision** shows the exact location of the revision, usually by an alphabetic indicator
        - 3. **Description** gives a brief description of the change, such as a size change, a new part, or an angular cut difference
        - 4. **Date** indicates the date the revision was approved and became effective
        - 5. **Approved By** usually abbreviated, this block shows the person who approved the individual change
- III. Determine the Scale of the View or Section
    - A. Check the title block for the overall scale of the drawing
    - B. Each detail view must be checked for scale
    - C. Notes on scale
        - 1. **Full or 1:1**--the part is drawn to its actual size
        - 2. **Half or 1/2:1**--the part is drawn to one-half its actual size
        - 3. Any other scale would be distinctly noted
- IV. The Word *Noted* in Any Block Indicates That the Desired Information Can Be Found Written Somewhere on the Drawing, Usually Very Close to the Area to Which it Applies

Name_______________________ Date_____________

MFG-C5
Verify Drawing Elements
Self-Assessment

Circle the letter preceding the correct answer.

1. The title block does *not* contain:
   - A. The name of the person who authorized the specific revision.
   - B. The identification number of the drawing it replaces.
   - C. The overall drawing scale.
   - D. All of the above can be found in the title block.
   - E. None of the above answers is correct.

2. Revision blocks:
   - A. Contain the exact physical location of the revision.
   - B. Identify the person who approved the revision.
   - C. Show the date of the revision.
   - D. All of the above information is in the revision block.
   - E. None o f the above answers is correct.

3. The word ___ indicates that the information can be found in the body of the drawing.
   - A. Referral
   - B. Detail
   - C. Noted
   - D. Incorporated
   - E. None of the above answers is correct.

4. The scale notation ___ means that the drawing is drawn to the same size as the part which it represents.
   - A. 1/2:1
   - B. 1:1
   - C. Full
   - D. Answers A anc C are the same and both are correct.
   - E. Answers B and C are the same and both are correct.

5. The scale notation 1/2:1:
   - A. Indicates that the drawing is one-half the size of the part.
   - B. Is the same as the notation *half.*
   - C. Is not commonly found.
   - D. Both A and B.
   - E. Both B and C.

6. A ___ is that portion of the drawing that is represented by an alphanumeric Cartesian coordinate.
   A. Region
   B. Zone
   C. Dimension
   D. All of the above answers are applicable.
   E. None of the above answers is correct.

7. Both the *Drawn By* date and the *Replaced By* identification can be found in the:
   A. Title block
   B. Revision list
   C. Bill of materials
   D. All of the above answers are correct.
   E. None of the above answers is correct.

8. Which of the following is *not located* in the revision list?
   A. Effective date
   B. Zone
   C. Description
   D. All of the above answers are correct.
   E. None of the above answers is correct.

9. The revision list is also known as the:
   A. Change list.
   B. Additions & Deletions list.
   C. Control block.
   D. Verification block.
   E. None of the above answers is correct.

10. Using obsolete blueprints can result in:
   A. Lost work.
   B. Loss of materials.
   C. Lowered profits.
   D. All of the above answers are correct.
   E. None of the above answers is correct.

MFG-C5
Verify Drawing Elements
Self-Assessment Answer Key

1. A
2. D
3. C
4. E
5. D
6. B
7. A
8. D
9. A
10. D

MFG-C6

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-C6

Subject: **Manufacturing Technology** **Time: 8 Hrs.**

Duty: **Interpret Engineering Drawings and Control Documents**
Task: Practice Geometric Dimensioning and Tolerancing (GD&T)

Objective(s):

Upon completion of this unit the student will be able to:
a. Identify the purpose of GD&T;
b. Identify symbols for controlling location (or true position) of part features;
c. Identify symbols for controlling form (or alignment) of part features;
d. Identify symbols for showing datums and basic dimensions on drawings; and,
e. Identify symbols for Maximum Material Size (MMS) and Regardless of Feature Size (RFS).

Instructional Materials:

MASTER Handout (MFG-C6-HO)
MASTER Self-Assessment
Blueprints with GD&T notations
Parts correspondent to the selected blueprints

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Tolerances and Fits"
Introduction to Geometric Dimensioning and Tolerancing, Lowell W. Foster, National Tooling & Machining Association, Latest Edition
Machinery's Handbook, Industrial Press, Latest Edition

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-C1 "Identify Basic Layout of Drawings"
MFG-C2 "Identify Basic Types of Drawings"
MFG-C3 "Review Blueprint Notes and Dimensions"
MFG-C4 "List the Purpose of Each Type of Drawing"
MFG-C5 "Verify Drawing Elements"

Introduction:

Geometric Dimensioning and Tolerancing is used whenever the location of the part is as critical or more critical than its actual size. GD&T actually ensures that parts from different manufacturers will mate properly or can be mutually substituted.

Presentation Outline:

I. Identify the Purpose of GD&T

In industry today, there are many companies competing for replacement parts to replace ones that have worn out. They are geared more towards, and can handle, part replacement better than the companies that made the original unit. Realizing this, manufacturers and the engineering community have used Geometric Dimensioning and Tolerancing to maintain replacement part unity. For example, a part for your car was originally made by Mammoth Motor Company; but when you go to a parts house, they supply you with a part from Acme Auto Parts.

II. Identify Symbols for Controlling Location (Or True Position) of Part Features

True position, Concentricity, and *Symmetry* are used to indicate location control. Many units have a particular bolt pattern; if you were to replace one of the two units with another unit made from a different manufacturer, it may not have the same bolt pattern and would not be compatible.

III. Identify Symbols for Controlling Form (Or Alignment) of Part Features

Perpendicularity (squareness) is one example of form that must be controlled during manufacturing. The following list of symbols indicate types of form control:

1. Straightness;
2. Flatness;
3. Angularity;
4. Parallelism;
5. Roundness;
6. Cylindricity
7. Profile of any line;
8. Profile of any surface; and,
9. Runout (circular or total).

IV. Identify Symbols for Showing Datums and Basic Dimensions on Drawings

Datums are reference points, lines, and planes taken to be exact for the purposes of calculation and measurement. They are placed in a rectangular frame and are identified by single or double letters. I, O, and Q are not used.

V. Identify Symbols for Maximum Material Condition (MMC) and Regardless of Feature Size (RFS)

A. (MMC) refers to the maximum amount of material remaining.

B. (RFS) refers to means that the form or position tolerance of a feature must be met no matter what the feature size is.

Practical Application:

Students will understand the uses and applications of GD&T and be able to recognize the symbols thereof.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-C7) dealing with the analysis of bills of materials.

MFG-C6-HO
Practice Geometric Dimensioning and Tolerancing (GD&T)
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify the purpose of GD&T;
b. Identify symbols for controlling location (or true position) of part features;
c. Identify symbols for controlling form (or alignment) of part features;
d. Identify symbols for showing datums and basic dimensions on drawings; and,
e. Identify symbols for Maximum Material Size (MMS) and Regardless of Feature Size (RFS).

Module Outline:

I. Identify the Purpose of GD&T
In industry today, there are many companies competing for replacement parts to replace ones that have worn out. They are geared more towards, and can handle, part replacement better than the companies that made the original unit. Realizing this, manufacturers and the engineering community have used Geometric Dimensioning and Tolerancing to maintain replacement part unity. For example, a part for your car was originally made by Mammoth Motor Company; but when you go to a parts house, they supply you with a part from Acme Auto Parts.

II. Identify Symbols for Controlling Location (Or True Position) of Part Features
True position, Concentricity, and *Symmetry* are used to indicate location control. Many units have a particular bolt pattern; if you were to replace one of the two units with another unit made from a different manufacturer, it may not have the same bolt pattern and would not be compatible.

III. Identify Symbols for Controlling Form (Or Alignment) of Part Features
Perpendicularity (squareness) is one example of form that must be controlled during manufacturing. The following list of symbols indicate types of form control:

1. Straightness;
2. Flatness;
3. Angularity;
4. Parallelism;
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6. Cylindricity
7. Profile of any line;
8. Profile of any surface; and,

9. Runout (circular or total).

IV. Identify Symbols for Showing Datums and Basic Dimensions on Drawings
Datums are reference points, lines, and planes taken to be exact for the purposes of calculation and measurement. They are placed in a rectangular frame and are identified by single or double letters. I, O, and Q are not used.

V. Identify Symbols for Maximum Material Condition (MMC) and Regardless of Feature Size (RFS)
  A. (MMC) refers to the maximum amount of material remaining.
  B. (RFS) refers to means that the form or position tolerance of a feature must be met no matter what the feature size is.

Name______________________________ Date________________

MFG-C6
Practice Geometric Dimensioning and Tolerancing
Self-Assessment

Circle the letter preceding the correct answer.

1. True position means location could be more important than actual size. Why is this important?
   A. Not all the parts of an assembly may be made of the same material.
   B. Not all the parts of an assembly may be made in the same factory.
   C. Not all the parts of an assembly may be made by the same manufacturer.
   D. All of the above answers are correct.
   E. None of the above answers is correct.

2. Geometric Dimensioning and Tolerancing was developed:
   A. By replacement parts manufacturers.
   B. To facilitate exchange ability of parts.
   C. To be a simple subject, quickly learned.
   D. All of the above answers are correct.
   E. None of the above answers is correct.

3. MMC refers to the:
   A. Maximum amount of material remaining.
   B. Minimum amount of material remaining.
   C. Maximum material condition.
   D. Minimum material condition.
   E. None of the above answers is correct.

4. RFS means that:
   A. The part must function, regardless of its size.
   B. The part's position tolerance is more important than its size.
   C. The lathe must turn at a *R*eally *F*ast *S*pin.
   D. All of the above answers are correct.
   E. None of the above answers are correct.

5. A *datum* is a ___ taken to be exact for the purpose of calculations and measurements.
   A. Reference point
   B. Line
   C. Plane
   D. All of the above answers are correct.
   E. None of the above answers is correct.

6. The symbol "//" indicates:
   A. Perpendicularity.
   B. Parallelism.
   C. Concentricity.
   D. There is no such symbol in GD&T.
   E. None of the above answers is correct.

7. The symbol "◎" indicates:
   A. Perpendicularity.
   B. Parallelism.
   C. Concentricity.
   D. There is no such symbol in GD&T.
   E. None of the above answers is correct.

8. $\boxed{.375}$ This box indicates that the number contained therein is:
   A. A basic dimension.
   B. An exact dimension.
   C. A positional indicator.
   D. Both A and C are correct.
   E. Answers A and B are the same and are correct.

9. ___ is an orientation tolerance.
   A. Perpendicularity.
   B. Parallelism.
   C. Angularity.
   D. All of the above are orientation tolerances.
   E. None of the above answers is correct.

10. Which of the following is *not* a form tolerance?
   A. Circularity
   B. Concentricity
   C. Cylindricity
   D. All of the above are form tolerances.
   E. None of the above answers is correct.

MFG-C6
Practice Geometric Dimensioning and Tolerancing
Self-Assessment Answer Key

1. C
2. B
3. C
4. B
5. D
6. B
7. C
8. E
9. D
10. B

MFG-C7

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-C7

Subject: **Manufacturing Technology** **Time: 2 Hrs.**

Duty: **Interpret Engineering Drawings and Control Documents**
Task: Analyze Bill of Materials (BOM)

Objective(s):

Upon completion of this unit the student will be able to:
a. Know which components are found on BOM;
b. Determine which materials are needed to produce the part;
c. Determine the quantities necessary to produce the part;
d. Submit a completed stock request form as required; and,
e. Submit a completed tool request form as needed.

Instructional Materials:

MASTER Handout (MFG-C7-HO)
MASTER Self-Assessment
Copies of blueprints with bills of materials

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Reading Drawings"
Blueprint Reading for Manufacturing, Edward G. Hoffman and Paul K. Wallach, Delmar Publishers, Inc., Latest Edition, "Detail and Assembly Prints"

Student Preparation:

Introduction:

Before anything can be built, its builder must know what to build it from. While the body of the drawing shows the positions and sizes of parts and all the necessary cuts and corners, the bill of materials tells which materials the machinist needs to complete the work at hand. This bill of materials may include commercially available parts, or may specify the necessary stock sizes.

Presentation Outline:

- I. Discuss Components Found on BOM
  - A. Item or Part Number, relative to the body of the drawing
  - B. Description of Item
  - C. Specification
  - D. Material Needed
  - E. Number Required
- II. Determine Materials Needed to Produce the Part
- III. Determine Quantities Necessary to Produce the Part
- IV. Submit Completed Stock Request Form as Required
  This topic is company-specific and must be designed at such level. The instructor is encouraged to be extremely general in comments, covering only those areas of stock requests that are universal in application.
- V. Submit Completed Tool Request Form as Needed
  Here, too, the instructor must generalize and emphasize that s/he is generalizing.

Practical Application:

Students will be able to recognize and analyze Bills of Materials and to complete the required stock request forms from the Bill of Materials.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-C8) dealing with the relationship between engineering drawings and planning.

MFG-C7-HO
Analyze Bill of Materials (BOM)
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Know which components are found on BOM;
b. Determine which materials are needed to produce the part;
c. Determine the quantities necessary to produce the part;
d. Submit a completed stock request form as required; and,
e. Submit a completed tool request form as needed.

Module Outline:

I. Discuss Components Found on BOM
    A. Item or Part Number, relative to the body of the drawing
    B. Description of Item
    C. Specification
    D. Material Needed
    E. Number Required
II. Determine Materials Needed to Produce the Part
III. Determine Quantities Necessary to Produce the Part
IV. Submit Completed Stock Request Form as Required
    This topic is company-specific and must be designed at such level. The instructor is encouraged to be extremely general in comments, covering only those areas of stock requests that are universal in application.
V. Submit Completed Tool Request Form as Needed
    Here, too, the instructor must generalize and emphasize that s/he is generalizing.

Name____________________________ Date_______________

MFG-C7
Analyze Bill of Materials (BOM)
Self-Assessment

Using the sample BOM, answer the questions below.

32	Key	1/4 x 1/4 x 1	Steel	3
24	Set Screw	3/8x1/4 - 16 NF	COMM	1
23	Ball Knob	P/N 15032	COMM	1
21	Handle	½ DIA	Naval Brass	1
Part Number	Description	Specification	Material	Number

1. Part #21 is made of _____.
2. Does the machinist have to make the ball knob? _______________
3. How many keys does the part require? ________________________
4. What are the dimensions of the keys? ________________________
5. What are the specifications for the set screw? _______________
6. Which part(s) is commercially available? _____________________
7. How many handles are required? ____________________________
8. What size is the ball knob? ________________________________
9. What is Part #24 in the drawing? ____________________________
10. Does the BOM imply that the grade of steel for the keys is critical?_____

MFG-C7
Analyze Bill of Materials (BOM)
Self-Assessment Answer Key

1. Naval Brass
2. No, the part is marked as commercially available.
3. Three (3)
4. 1/4 x 1/4 x 1
5. 3/8 x 1/4 - NF
6. Set Screw and Ball Knob
7. One (1)
8. The size of the ball knob is not specified in the BOM because the part is commercially available. Any answer indicating this, including "Unknown" or "Not Specified" is acceptable.
9. Set Screw
10. No, there is no specification for the type or strength of the steel.

MANUFACTURING TECHNOLOGY SERIES
MASTER Technical Module No. MFG-C8

Subject: **Manufacturing Technology** **Time: 4 Hrs.**

Duty: **Interpret Engineering Drawings and Control Documents**
Task: Describe the Relationship of Engineering Drawings to Planning

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Objective(s):

Upon completion of this unit the student will be able to:
a. Discuss production schedules;
b. Understand Material Resource Planning (MRP);
c. Recognize and utilize inventory control records; and,
d. Recognize and follow specific shop floor routing documents.

Instructional Materials:

MASTER Handout (MFG-C8-HO)
MASTER Self-Assessment
All instructional materials should be specific to a particular shop, if possible. General documents may be used in other cases.
Shop-floor routing documents
Receipt of Goods documents
Waste Management documents
Return of Goods documents
Tool Room accounts and documents
Machine Time documents

References:

Student Preparation:

Introduction:

In a perfect world, all shops would get exactly the materials they needed at the exact moment that they needed them. This is not a perfect world. Profit drives scheduling, and well-organized, well-run shops are more profitable than those that are not so well run.

At the heart of organization is planning. Planning is driven by the customer, who places an order and agrees to a delivery date. Happy customers are the result of excellence not only in product performance, but also in service. Critical to excellence in service is timely delivery of the promised product which goes back to (you guessed it) planning.

Presentation Outline:

I. Discuss Production Schedule
  A. Internal Factors
    1. Available personnel and equipment
    2. Priority
    3. Setup time
    4. Parts per man-hour (quotas)
    5. Warehouse to shop floor time for stock
    6. Shop floor to shipping department time for parts
  B. External factors
    1. Customer deadlines
    2. Material delivery schedules
II. Discuss Material Resource Planning (MRP)
  A. Volume of production
  B. Required stock
    1. Types of stock needed
    2. Amounts of stock needed
  C. Waste management
  D. Mechanical management
    1. Tool wear and replacement
    2. Machine down-time
III. Discuss Inventory Control Records
  A. Receipt of goods documents
  B. Waste management documents
  C. Return of goods documents
  D. Tool room accounts and documents
  E. Machine time documents
IV. Discuss Shop Floor Routing Documents
  These documents vary in detail from shop to shop. The instructors should use documents from their own shops to explain both the theory and practice of routing documents.

Practical Application:

All students should be able to understand their roles in the production schedule and the importance of the documentation of the stock, parts, and tools to production and profitability.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-C9) dealing with understanding quality systems and the machinist's role in quality.

MFG-C8-HO
Describe the Relationship of Engineering Drawings to Planning
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Discuss production schedules;
b. Understand Material Resource Planning (MRP);
c. Recognize and utilize inventory control records; and,
d. Recognize and follow specific shop floor routing documents.

Module Outline:

I. Discuss Production Schedule
   A. Internal Factors
      1. Available personnel and equipment
      2. Priority
      3. Setup time
      4. Parts per man-hour (quotas)
      5. Warehouse to shop floor time for stock
      6. Shop floor to shipping department time for parts
   B. External factors
      1. Customer deadlines
      2. Material delivery schedules

II. Discuss Material Resource Planning (MRP)
   A. Volume of production
   B. Required stock
      1. Types of stock needed
      2. Amounts of stock needed
   C. Waste management
   D. Mechanical management
      1. Tool wear and replacement
      2. Machine down-time

III. Discuss Inventory Control Records
   A. Receipt of goods documents
   B. Waste management documents
   C. Return of goods documents
   D. Tool room accounts and documents
   E. Machine time documents

IV. Discuss Shop Floor Routing Documents

These documents vary in detail from shop to shop. The instructors should use documents from their own shops to explain both the theory and practice of routing documents.

Name______________________________ Date_________________

MFG-C8
Describe the Relationship of Engineering Drawings to Planning
Self-Assessment

Circle the letter preceding the correct answer.

1. When determining the amount of materials needed for production, the technician should consult:
   A. The original order.
   B. The blueprint BOM.
   C. The inventory report.
   D. All of the above should be consulted.
   E. None of the above answers is correct.

2. A part run requires five hundred pieces. If five pieces can be made from one three-foot piece of 1" CRS, how many such pieces does the technician need to complete the run? Assume 1% waste.
   A. 99
   B. 100
   C. 101
   D. This is a problem for the engineers to solve before it gets to me.
   E. None of the above answers is correct.

3. One technician can make one hundred good widgets in four hours. What is the technician's production in parts per man-hour? Assume 4% waste.
   A. 20
   B. 25
   C. 26
   D. 12.5
   E. None of the above answers is correct.

4. The technician is receiving fifty pieces of stock for a production run. What should the technician do *before* signing the receipt of goods?
   A. Verify the type of material listed.
   B. Verify the amount of material listed.
   C. Nothing
   D. Both A and B
   E. None of the above answers is correct.

5. **If a particular tool wears out after 300 hours of contact, and five parts can be cut with it in one hour, how many parts will the tool cut before it needs to be replaced?**
   A. **60**
   B. **300**
   C. **1500**
   D. **None of the above answers is correct.**

6. **If six technicians make one hundred twenty parts in thirty minutes, what is their production per man-hour?**
   A. **20**
   B. **40**
   C. **120**
   D. **240**
   E. **None of the above answers is correct.**

7. A part is produced at a rate of twelve per man hour. An emergency order has come in for 60 such parts to be picked up in two hours. How many technicians are needed to produce the part? Assume that all other factors of production consume one hour of the allotted time.
   A. 3
   B. 4
   C. 5
   D. 6
   E. None of the above answers is correct.

Questions 8, 9, and 10 all deal with routing of parts and materials through the shop. Instructors should compose these questions from their available documents.

MFG-C8

Describe the Relationship of Engineering Drawings to Planning

Self-Assessment Answer Key

1. B
2. C
3. B
4. D
5. C
6. B
7. C
8.
9.
10.

MFG-C9

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-C9

Subject: **Manufacturing Technology** **Time: 32 Hrs.**

Duty: **Interpret Engineering Drawings and Control Documents**
Task: Understand and Use Quality Systems

Objective(s):

Upon completion of this unit the student will be able to:
a. Understand and apply quality principles, including continuous improvement; and,
b. Document paper trails for part revisions.

Instructional Materials:

MASTER Handout (MFG-C9-HO)

References:

Student Preparation:

Introduction:

The ultimate goal of all technicians is to fabricate perfect parts and make absolute repairs. Unfortunately, we just can't get there from here. However, with the consistent application of quality controls *at every level*, we can get close.

Presentation Outline:

I. Understand and Apply Quality Principles, Including Continuous Improvement
  A. Tolerances as basic quality control
  B. The machinist as the first line of excellence
  C. Specific systems
  These systems are diverse. You, as the instructor, must tailor this portion of the lecture to the system used in your circumstances.
  D. The inspector as guarantor
  E. The consumer: the ultimate judge of top quality

II. ISO 9000
   A. Purpose
   B. What is ISO 9000?
   C. How does is work?
   D. Where do the standards come from?
   E. Who uses this stuff, anyway?

III. Document Paper Trails for Part Revisions

Practical Application:

Due to the large number of quality assurance systems, the instructor must tailor the Self-Assessment to his own company.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-C10) discussing the use of standards and the verification of requirements.

MFG-C9-HO
Understand and Use Quality Systems
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Understand and apply quality principles, including continuous improvement; and,
- b. Document paper trails for part revisions.

Module Outline:

- I. Understand and Apply Quality Principles, Including Continuous Improvement
  - A. Tolerances as basic quality control
  - B. The machinist as the first line of excellence
  - C. Specific systems
    These systems are diverse. You, as the instructor, must tailor this portion of the lecture to the system used in your circumstances.
  - D. The inspector as guarantor
  - E. The consumer: the ultimate judge of top quality
- II. ISO 9000
  - A. Purpose
  - B. What is ISO 9000?
  - C. How does is work?
  - D. Where do the standards come from?
  - E. Who uses this stuff, anyway?
- III. Document Paper Trails for Part Revisions

MFG-C10

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-C10

Subject: **Manufacturing Technology** **Time: 4 Hrs.**

Duty: **Interpret Engineering Drawings and Control Documents**
Task: Verify Standard Requirements

Objective(s):

Upon completion of this unit the student will be able to:

a. Discuss the purpose of standards; and,
b. Discuss source locations for standards.

Instructional Materials:

MASTER Handout (MFG-C10-HO)
The instructor must use corporate resources, such as obsolete plans and masters
Steel rule (any)
Representative gage blocks (any)
Sample of any metal showing a control stamp

References:

Machinery's Handbook, Industrial Press, Latest Edition

Student Preparation:

Students shall have completed all MFG C-series modules.

Introduction:

Long before Henry Ford introduced modern manufacturing with his assembly lines, even before Samuel Colt mass-produced interchangeable cylinders for his pistols, the principles of reproducibility were introduced in France. In the waning days of the Eighteenth Century, French women bombarded the cloth industry with demands for complex, repeating patterns for their dresses. Single colors and unique designs were no longer acceptable to the French nobility. From this demand, the Jacquard loom arose. This revolutionary loom gave rise, ultimately, to the computer; but that is a different story. What is important here is that Monsieur Jacquard established a *definite, repeatable standard* for a mass-production industry. And, while he was not the first to try to do so, he was the first to succeed on such a large scale. The Jacquard loom required that wooden cards be cut with identical patterns of holes which controlled the operation of the loom; this lead to the use of brass masters against which all wooden cards were measured. The practice of having a physical unit standard, against which all others were measured, was in use until late in the Twentieth Century, when atomic emissions made platinum-iridium bars obsolete. In a world demanding reproducible, interchangeable parts, even for patterns in cloth, standards are utterly indispensable.

Presentation Outline:

- I. Discuss the Purpose of Standards
  - A. What are standards, anyway?
  - B. Why have standards at all?
  - C. How does a technician use today's standards?
  - D. The technician's role in quality as it relates to standards.
- II. Discuss Source Locations for Standards
  - A. Shop/company sources—*Machinery's Handbook,* especially
  - B. Industry sources
  - C. Governmental sources
- III. Oral Shorthand—Nominal Sizes vs. Actual Sizes

Practical Application:

The students will be able to look up and interpret standards of measurement, tolerances, and masters.

Evaluation and/or Verification:

This module has no Self-Assessment. The evaluation and verification of the student's understanding of the principles and uses of standards are on-going throughout the *entire course* of study. The instructor may, however, decide to have the students study the several charts found in *Machinery's Handbook* to increase their understanding of standard sizes and tolerances.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-D1) dealing with identifying and selecting materials with desired properties.

MFG-C10-HO
Verify Standard Requirements
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Discuss the purpose of standards; and,
- b. Discuss source locations for standards.

Module Outline:

- I. Discuss the Purpose of Standards
  - A. What are standards, anyway?
  - B. Why have standards at all?
  - C. How does a technician use today's standards?
  - D. The technician's role in quality as it relates to standards.
- II. Discuss Source Locations for Standards
  - A. Shop/company sources—*Machinery's Handbook,* especially
  - B. Industry sources
  - C. Governmental sources
- III. Oral Shorthand—Nominal Sizes vs. Actual Sizes

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/decimals	B-3 Convert Metric/English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

Duty D

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-D1

Subject: Manufacturing Technology **Time:** 2 Hrs.

Duty: Recognize Different Manufacturing Materials and Processes
Task: Identify Materials With Desired Properties

Objective(s):

Upon completion of this unit the student will be able to:

a. Discuss classification system for metals; and,
b. Describe general characteristics for carbon steels, tool steels, stainless steels, structural steels, cast irons, aluminum, and other commonly used metals.

Instructional Materials:

MASTER Handout (MFG-D1-HO1)
The following tables are included in this module for reference or reproduction as needed.

Table 1.1	"Effects of Alloying Elements on Steel" (MFG-D1-HO2)
Table 1.2	"SAE-ANSI Numerical Designation of Alloy Steels" (MFG-D1-HO3)

MASTER Self-Assessment

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Selection and Identification of Steels" and "Selection and Identification of Non-Ferrous Metals"

NTMA Modules:

MA-II-46	"Physical Metallurgy"
MA-II-77	"Cast Irons"
MA-II-48	"Property of Metals"
MA-II-79	"Powder Metallurgy"
MA-II-50	"Iron Carbon Constitutional Diagram"
MA-II-57	"Steel Classification & Basic Tests for Identifying the Content of an Unknown Metal"
MA-II-59	"Plain Carbon Steel"
MA-II-67	"Alloy Steels and Stainless Steels"
MA-II-69	"Aluminum & Aluminum Alloys"
MA-II-71	"Magnesium & Magnesium Alloys"

MA-II-73 “Copper & Copper Alloys”
MA-II-75 “Other Nonferrous Metals & Cast Alloys”
Machinery's Handbook, Industrial Press, Latest Edition

Student Preparation:

None

Introduction:

It has become increasingly important for the machinist to understand the properties of metals during the last few years. With more and more emphasis on weight reduction and increased strength in products such as automobiles and aircraft, the machinist will be expected to work with many different types of carbon and alloy steels. So it is imperative that the machinist understand the properties and identification system for metals commonly found in the machine shop.

Presentation Outline:

I. Discuss the Physical Properties of Metal
  A. Brittleness - the property of a metal which permits no permanent distortion before breaking
  B. Ductility - the ability of the metal to be permanently deformed without breaking
  C. Elasticity - the ability of a metal to return to its original shape after any force acting upon it has been removed
  D. Hardness - the resistance to forcible penetration
  E. Malleability - the property of a metal which permits it to be hammered or rolled into other sizes and shapes
  F. Tensile strength - the maximum amount of pull that a material will withstand before breaking
  G. Toughness - the property of a metal to withstand shock or impact
II. Discuss the Classification System for Steel
  A. Carbon steels
    1. Low carbon steel - contains from 0.02 to 0.20 percent of carbon
    2. Medium carbon steel - contains from 0.30 to 0.60 percent of carbon
    3. High carbon steel (tool steel) - contains over 0.60 percent of carbon
  B. Alloy steels - alloying elements allow steels to possess special characteristics
    Discuss Table 1.1 “Effects of Alloying Elements on Steel”
    Discuss Table 1.2 “SAE-ANSI Numerical Designation of Alloy Steels”
III. Describe General Characteristics For:

A. Carbon Steels
B. Tool Steels
C. Stainless Steels
D. Structural Steels
E. Cast Irons
F. Non-Ferrous Metals
    1. Aluminum and Its Alloys
    2. Copper and Its Alloys
    3. Nickel Alloys
    4. Precious Metals
    5. Others

Practical Application:

Students will be able to select metals based on their properties through understanding their physical characteristics and the standard coding system.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions

Next Lesson Assignment:

MASTER Technical Module (MFG-D2) dealing with the identification of materials and processes used to produce a part.

MFG-D1-HO1
Identify Materials with Desired Properties
Attachment 1: **MASTER** Handout No. 1

Objective(s):

Upon completion of this unit the student will be able to:

- a. Discuss classification system for metals; and,
- b. Describe general characteristics for carbon steels, tool steels, stainless steels, structural steels, cast irons, aluminum, and other commonly used metals.

Module Outline:

- I. Discuss the Physical Properties of Metal
  - A. Brittleness - the property of a metal which permits no permanent distortion before breaking
  - B. Ductility - the ability of the metal to be permanently deformed without breaking
  - C. Elasticity - the ability of a metal to return to its original shape after any force acting upon it has been removed
  - D. Hardness - the resistance to forcible penetration
  - E. Malleability - the property of a metal which permits it to be hammered or rolled into other sizes and shapes
  - F. Tensile strength - the maximum amount of pull that a material will withstand before breaking
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- II. Discuss the Classification System for Steel
  - A. Carbon steels
    - 1. Low carbon steel - contains from 0.02 to 0.20 percent of carbon
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    - 3. High carbon steel (tool steel) - contains over 0.60 percent of carbon
  - B. Alloy steels - alloying elements allow steels to possess special characteristics
    Discuss Table 1.1 "Effects of Alloying Elements on Steel"
    Discuss Table 1.2 "SAE-ANSI Numerical Designation of Alloy Steels"
- III. Describe General Characteristics For:
  - A. Carbon Steels
  - B. Tool Steels
  - C. Stainless Steels
  - D. Structural Steels
  - E. Cast Irons

F. Non-Ferrous Metals
    1. Aluminum and Its Alloys
    2. Copper and Its Alloys
    3. Nickel Alloys
    4. Precious Metals
    5. Others

MFG-D1-HO2
Identify Materials With Desired Properties
Attachment 2: MASTER Handout No. 2

TABLES FOR MFG-D1 — PROPERTIES OF METALS
TABLE 1.1

THE EFFECT OF ALLOYING ELEMENTS ON STEEL

EFFECT	ELEMENT											
	Carbon	Chromium	Cobalt	Lead	Manganese	Molybdenum	Nickel	Phosphorus	Silicon	Sulfur	Tungsten	Vanadium
Increases tensile strength	X	X			X	X	X					
Increases hardness	X	X										
Increases wear resistance	X	X			X		X				X	
Increases hardenability	X	X			X	X	X					X
Increases ductility					X							
Increases elastic limit		X				X						
Increases rust resistance		X					X					
Increases abrasion resistance		X			X							
Increases toughness		X				X	X					X
Increases shock resistance		X					X					X
Increases fatigue resistance												X
Decreases ductility	X	X										
Decreases toughness			X									
Raises critical temperature		X	X								X	
Lowers critical temperature					X		X					
Causes hot shortness										X		
Causes cold shortness								X				
Imparts red hardness			X			X					X	
Imparts fine grain structure					X							X
Reduces deformation					X		X					
Acts as deoxidizer					X				X			
Acts as desulphurizer					X							
Imparts oil hardening properties		X			X	X	X					
Imparts air hardening properties					X	X						
Eliminates blow holes								X				
Creates soundness in casting									X			
Facilitates rolling and forging					X				X			
Improves machinability				X						X		

MFG-D1-HO3
Identify Materials With Desired Properties
Attachment 3: MASTER Handout No. 3

TABLE 1.2

SAE-AISI NUMERICAL DESIGNATION OF ALLOY STEELS *(X Represents Percent of Carbon in Hundredths)*	
Carbon Steels	
Plain carbon	10xx
Free-cutting, resulfurized	11xx
Manganese Steels	13xx
Nickel Steels	
.50% nickel	20xx
1.50% nickel	21xx
3.50% nickel	23xx
5.00% nickel	25xx
Nickel-Chromium Steels	
1.25% nickel, .65% chromium	31xx
1.75% nickel, 1.00% chromium	32xx
3.50% nickel, 1.57% chromium	33xx
3.00% nickel, .80% chromium	34xx
Corrosion and heat-resisting steels	303xx
Molybdenum Steels	
Chromium	41xx
Chromium-nickel	43xx
Nickel	46xx and 48xx
Chromium Steels	
Low-chromium	50xx
Medium-chromium	511xx
High-chromium	521xx
Chromium-Vanadium Steels	6xxx
Tungsten Steels	7xxx and 7xxxx
Triple-Alloy Steels	8xxx
Silicon-Manganese Steels	9xxx
Leaded steels	11Lxx (example)

Name______________________________ Date_________________

MFG-D1
Identify Materials With Desired Properties
Self-Assessment

Circle the letter preceding the correct answer.

1. Using the SAE system, 1008 indicates:
   - A. Plain carbon steel, 8% carbon.
   - B. Plain carbon steel, 0.8% carbon
   - C. Plain carbon steel, 0.08% carbon.
   - D. Low-chromium steel, 0.08% carbon.
   - E. None of the above answers is correct.

2. In the SAE system, triple-alloy steels are designated by the numeral:
   - A. 6
   - B. 7
   - C. 8
   - D. 9
   - E. None of the above answers is correct.

3. The AISI system uses ___ to indicate the process used to manufacture the steel.
   - A. Numerical prefixes
   - B. Numerical suffixes
   - C. Capital-letter prefixes
   - D. Capital-letter suffixes
   - E. None of the above answers is correct.

4. Which of the following does *not* increase the tensile strength of steel?
   - A. Carbon
   - B. Molybdenum
   - C. Nickel
   - D. All of the above elements increase the tensile strength of steel.
   - E. None of the above answers is correct.

5. Which of the following elements decreases the *toughness* of steel?
   - A. Cobalt
   - B. Phosphorus
   - C. Vanadium
   - D. All of the above elements increase the toughness of steel.
   - E. None of the above answers is correct.

6. Which of the following elements imparts *fine grain structure* to steel?
   A. Chromium
   B. Manganese
   C. Silicon
   D. Tungsten
   E. None of the above answers is correct.

7. The AISI prefix *B* designates that the steel is:
   A. Acid Bessemer carbon steel.
   B. Basic open hearth carbon steel.
   C. Acid open hearth carbon steel.
   D. Brass.
   E. None of the above answers is correct.

8. ___ steels have their own alphabetic classification system.
   A. Stainless
   B. Low-carbon
   C. Tool
   D. Austenitic
   E. None of the above answers is correct.

9. ___ stainless steel cannot be hardened by quenching.
   A. Austenitic
   B. Ferritic
   C. Martensitic
   D. All of the above stainless steels can be hardened by quenching.
   E. None of the above answers is correct.

10. Which of the following metals is magnetic?
   A. Phosphorus
   B. Silicon
   C. Sulfur
   D. All of the above metals are magnetic.
   E. None of the above answers is correct.

MFG-D1
Identify Materials With Desired Properties
Self-Assessment Answer Key

1. C
2. C
3. C
4. D
5. A
6. B
7. A
8. C
9. A
10. E

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-D2

Subject: **Manufacturing Technology** **Time: 6 Hrs.**

Duty: **Recognize Different Manufacturing Materials and Processes**
Task: Identify Materials and Processes to Produce a Part

Objective(s):

Upon completion of this unit the student will be able to:

a. Briefly describe and list the advantages and disadvantages for each of the following: casting processes, hot working processes, and cold working processes;
b. Discuss service requirements (strength, hardness, etc.);
c. Discuss fastening processes (fasteners, welding, bonding, etc.); and,
d. Discuss corrosion resistance methods.

Instructional Materials:

MASTER Handout (MFG-D2-HO)
MASTER Self Assessment
Several samples of parts treated to resist corrosion by different methods
Several fasteners and samples of different bonding agents
Samples of metals showing exemplary welds
Samples of parts made by each process covered by the instructor

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, Section on "Materials"
Machinery's Handbook, Industrial Press, Latest Edition

Student Preparation:

Students should have previously completed the following Technical Module:
MFG-D1 "Identify Materials with Desired Properties"

Introduction:

As in all other crafts, the materials of machining determine the properties of the part. While two pieces may appear the same to the naked eye, different metals have different strengths; and the two pieces may differ markedly in their performance.

Therefore, the machinist must be capable of identifying not only the material itself, but also its working properties.

Presentation Outline:

I. Describe Casting Processes
    A. Discuss the following casting processes: sand, evaporative, shell molding, permanent mold, centrifugal, investment, and die casting
    B. Discuss pattern and mold design factors for each of the above casting processes
    C. List the advantages and disadvantages of the casting processes
II. Describe Hot Working Processes
    A. Discuss the following hot working processes: rolling, strand casting, forging, drawing, extrusion, spinning, and roll forming
    B. List the advantages and disadvantages of the hot working processes
III. Describe Cold Working Processes
    A. Discuss the following cold working processes: rolling, blanking, pressing, drawing, extruding, wire and bar drawing, bending, shearing, and roll forming
    B. List the advantages and disadvantages of the cold working process
IV. Evaluate Alternative Manufacturing Processes
    A. Discuss the powder metallurgy process (PM)
    B. Discuss the following nontraditional machining processes: EDM, laser machining, ultrasonic machining, hydrojet machining, electron beam machining, and plasma beam machining

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Practical Application:

Students will be able to recognize fasteners forms, casting processes, and novel machining methods and to readily identify the uses and advantages of each.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-D3) dealing with the heat treating process

MFG-D2-HO
Identify Materials and Processes to Produce a Part
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Briefly describe and list the advantages and disadvantages for each of the following: casting processes, hot working processes, and cold working processes;
b. Discuss service requirements (strength, hardness, etc.);
c. Discuss fastening processes (fasteners, welding, bonding, etc.); and,
d. Discuss corrosion resistance methods.

Module Outline:

I. Describe Casting Processes
  A. Discuss the following casting processes: sand, evaporative, shell molding, permanent mold, centrifugal, investment, and die casting
  B. Discuss pattern and mold design factors for each of the above casting processes
  C. List the advantages and disadvantages of the casting processes
II. Describe Hot Working Processes
  A. Discuss the following hot working processes: rolling, strand casting, forging, drawing, extrusion, spinning, and roll forming
  B. List the advantages and disadvantages of the hot working processes
III. Describe Cold Working Processes
  A. Discuss the following cold working processes: rolling, blanking, pressing, drawing, extruding, wire and bar drawing, bending, shearing, and roll forming
  B. List the advantages and disadvantages of the cold working process
IV. Evaluate Alternative Manufacturing Processes
  A. Discuss the powder metallurgy process (PM)
  B. Discuss the following nontraditional machining processes: EDM, laser machining, ultrasonic machining, hydrojet machining, electron beam machining, and plasma beam machining

Name________________________ Date______________

MFG-D2
Identify Materials and Processes to Produce a Part
Self-Assessment

Circle the letter preceding the correct answer.

1. In ___ casting, the mold is composed of sand and resin.
   A. Green-sand
   B. Shell
   C. V-process
   D. Squeeze
   E. None of the above answers is correct.

2. Which of the following is *not* a method of injecting material into a mold?
   A. Gravitic flow
   B. Pressure
   C. Centrifugal force
   D. All of the above are methods of injecting material into a mold.
   E. None of the above answers is correct.

3. What is the *skin effect?*
   A. The vacuoles created when the surface of a casting cools faster than its interior
   B. The thin, weak, exterior layer on castings caused by improper mixing of alloys
   C. The layers of metal formed in die casting
   D. Abrasions caused by excessive polishing of the casting
   E. Goose bumps

4. Die castings should be designed with ___ to relieve cooling stresses.
   A. Cores of simple shapes
   B. Heavy sections
   C. Small cores
   D. Uniform wall thicknesses
   E. None of the above answers is correct.

5. Which of the following is a major problem of the hot extrusion process?
   A. Cost of glass-powder lubricants
   B. Graphite lubricants contaminating the billet
   C. Construction of the equipment
   D. Scarcity of metals that can be successfully extruded
   E. None of the above answers is correct.

6. Extrusion generates ___ force, but not ___ force.
   A. Tensile. . .compressive
   B. Tensile. . .shear
   C. Compressive. . .shear
   D. Compressive. . .tensile
   E. None of the above answers is correct.

7. Plasma cutters can generate heat in excess of:
   A. 20,000°F.
   B. 30,000°F.
   C. 40,000°F.
   D. 80,000°F.
   E. 120,000°F.

8. Which of the following is *not* an advantage of EDM?
   A. Localized heat treating
   B. Extremely fine detail is possible.
   C. Can be used on very hard metals.
   D. All of the above answers are valid.
   E. None of the above answers is correct.

9. Which of the following processes would be most advantageous for internal deburring operations?
   A. ECDB
   B. Hydrojet machining
   C. Plasma machining
   D. Laser machining
   E. None of the above answers is correct.

10. What is meant by *ELG?*
   A. Extremely Large Gauge
   B. Electrolytic Grinding
   C. Emerald Laser Grinding
   D. Electron-Lathe Guide
   E. None of the above answers is correct.

MFG-D2

Identify Materials and Processes to Produce a Part

Self-Assessment Answer Key

1. B
2. D
3. C
4. D
5. C
6. D
7. C
8. A
9. A
10. B

MFG-D3

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-D3

Subject: **Manufacturing Technology** **Time: 4 Hrs.**

Duty: **Recognize Different Manufacturing Materials and Processes**
Task: Describe the Heat Treating Process

Objective(s):

Upon completion of this unit the student will be able to:

a. Discuss the reasons for heat treating;
b. Discuss the time/temperature chart;
c. List the different quenching media;
d. Estimate metal heat temperature by color; and,
e. List reasons for stress relieving workpieces.

Instructional Materials:

MASTER Handout (MFG-D3-HO)
MASTER Self-Assessment
Samples of various metals that have been treated
Samples of the non-toxic treatment media

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Hardening, Case Hardening, and Tempering" and "Annealing, Normalizing, and Stress Relieving"
Machinery's Handbook, Industrial Press, Latest Edition, Heat Treatment of Steel

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-D1 "Identify Materials with Desired Properties"
MFG-D2 "Identify Materials and Processes to Produce a Part"

Introduction:

Treating metals with rapid temperature changes to strengthen them is an ancient practice, dating back at least to the Eighth Century. Many archaeologists believe that the practice of *quenching* was greatly improved in Damascus about 700 AD purely by accident! It seems that the ruler of the city did not like the executions of criminals to be a messy, bloody spectacle. The Arabs already knew that wounds could be cauterized, and so the Emir ordered his executioner to heat his sword before each execution. The executioner soon discovered the difference in the sword, and it was not long before the practice spread. The first common quenching medium (other than plain water) was probably lamb's blood. Today, while there are much better media for quenching, the principle remains the same—certain chemicals, absorbed from the medium by the metal, change the strength of the part.

Presentation Outline:

I. Discuss the Reasons for Heat Treating
  A. Hardening for utility
  B. Tempering for toughness without brittleness
II. Discuss the Time/Temperature Chart
III. List the Different Quenching Media (In order of *severity* or speed of quenching)
  A. Brine (water and sodium chloride or sodium hydroxide)
  B. Water
  C. Fused (liquid) salts
  D. Molten lead
  E. Soluble oil and water
  F. Oil
  G. Air
IV. Estimate Metal Heat Temperature by Color
  A. Use of the temper color chart for tempering

Temperature (F)	Temperature (C)	Oxide Color	Suggested Uses
425	220	Light Straw	Steel-cutting tools
462	240	Dark Straw	Punches & Dies
490	258	Gold	Shear blades
500	260	Purple	Wood-cutting tools
540	282	Violet	Screwdrivers
580	304	Pale Blue	Springs
620	327	Steel Grey	None

  B. *Chicken Wire* markings warn of overheating.
V. List Reasons for Stress Relieving Workpieces
  A. Increased machinability

B. Increased workability in cold processes
VI. Special Safety Concerns of Heat Treating
A. Protective Gear against. . .
1. Heat
2. Fumes
3. Concussion
B. Toxicity of Certain Media
VII. Special Problems in Heat Treating
A. Brittleness
B. Distortion
C. Discoloration (sometimes unimportant)
D. Inadvertant heat treating

Practical Application:

Students will be able to:
a. Safely handle metals during heat treatment;
b. Recognize and control problems involved in heat treatment;
c. Curtail inadvertent heat treatment;
d. Discuss the reasons for heat treating;
e. Use the time/temperature chart;
f. Recognize and use the different quenching media;
g. Estimate metal heat temperature by color; and,
h. List reasons for stress relieving workpieces.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-D4) dealing with the testing of metal samples for hardness.

MFG-D3-HO
Describe the Heat Treating Process
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:
a. Discuss the reasons for heat treating;
b. Discuss the time/temperature chart;
c. List the different quenching media;
d. Estimate metal heat temperature by color; and,
e. List reasons for stress relieving workpieces.

Module Outline:

I. Discuss the Reasons for Heat Treating
  A. Hardening for utility
  B. Tempering for toughness without brittleness
II. Discuss the Time/Temperature Chart
III. List the Different Quenching Media (In order of *severity* or speed of quenching)
  A. Brine (water and sodium chloride or sodium hydroxide)
  B. Water
  C. Fused (liquid) salts
  D. Molten lead
  E. Soluble oil and water
  F. Oil
  G. Air
IV. Estimate Metal Heat Temperature by Color
  A. Use of the temper color chart for tempering

Temperature (F)	Temperature (C)	Oxide Color	Suggested Uses
425	220	Light Straw	Steel-cutting tools
462	240	Dark Straw	Punches & Dies
490	258	Gold	Shear blades
500	260	Purple	Wood-cutting tools
540	282	Violet	Screwdrivers
580	304	Pale Blue	Springs
620	327	Steel Grey	None

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B. *Chicken Wire* markings warn of overheating.
V. List Reasons for Stress Relieving Workpieces
A. Increased machinability
B. Increased workability in cold processes
VI. Special Safety Concerns of Heat Treating
A. Protective Gear against. . .
1. Heat
2. Fumes
3. Concussion
B. Toxicity of Certain Media
VII. Special Problems in Heat Treating
A. Brittleness
B. Distortion
C. Discoloration (sometimes unimportant)
D. Inadvertent heat treating

Name____________________________ Date_______________

MFG-D3

Describe the Heat Treating Process

Self-Assessment

Circle the letter preceding the correct answer.

1. What is the approximate temperature required for stress relief annealing of low-carbon steels?
   - A. 950°
   - B. 1000°
   - C. 1950°
   - D. 1700°
   - E. None of the above answers is correct.

2. What crystalline processes result from stress relief annealing?
   - A. All grains reform into softer grains.
   - B. Distorted grains reform into softer grains.
   - C. Ferrite grains reform into softer grains while pearlite grains are basically unaffected.
   - D. Pearlite grains reform into softer grains while ferrite grains are basically unaffected.
   - E. None of the above answers is correct.

3. Which of the following is *not* a cause of quenching cracks?
   - A. Improper quenching medium
   - B. Overheating during the austenitizing cycle
   - C. Improper quenching angle
   - D. All of the above are causes of quenching cracks.
   - E. None of the above answers is correct.

4. Which of the following is *not* a characteristic of typical quench cracks?
   - A. The fracture tends to run from the surface toward the center in a smooth curve.
   - B. Untempered quench cracks will not show any decarburization.
   - C. Tempered fracture surfaces will show a fine crystalline structure.
   - D. All of the above are characteristic of quench cracks.
   - E. None of the above answers is correct.

5. During tempering by color, which of the following colors represents the highest temperature?
   - A. Gold
   - B. Purple
   - C. Dark Straw
   - D. Pale Blue
   - E. Violet

6. During tempering by color, which of the following colors represents the lowest temperature?
   - A. Gold
   - B. Purple
   - C. Dark Straw
   - D. Pale Blue
   - E. Violet

7. What is meant by *step quenching?*
   - A. The workpiece is first quenched in a slow medium (e. g., air) then in a fast medium (e. g., water).
   - B. The workpiece is first quenched in a fast medium (e. g., water) then in a slow medium (e. g., air).
   - C. The weaker parts of the workpiece are quenched separately from the main body of the workpiece.
   - D. The workpiece is lowered into the quenching medium in steps, so that different parts of the workpiece attain different hardnesses.
   - E. None of the above answers is correct.

8. What is the simplest thing that the technician can do to minimize the vapor-blanket stage of liquid quenching?
   - A. Agitate the workpiece or the medium.
   - B. Heat the quenching medium to just below its boiling point.
   - C. Quickly insert the workpiece into the medium.
   - D. Slowly insert the workpiece into the medium.
   - E. None of the above answers is correct.

9. Liquid carburizing, as used in case hardening, utilizes ___ and is therefor extremely dangerous.
   - A. Sodium Chloride
   - B. Calcium Carbonate
   - C. Cyanide salts
   - D. Ammonia
   - E. None of the above answers is correct.

10. Workpieces which have been cut with an oxyacetylene torch often display edge hardness because:

A. The torch was starved for oxygen.
B. The workpiece was cut at too low a temperature.
C. The wrong type of cutting torch was used.
D. Oxyacetylene torches always leave hardened edges.
E. None of the above answers is correct.

MFG-D3
Describe the Heat Treating Process
Self-Assessment Answer Key

1. A
2. C
3. D
4. A
5. C
6. D
7. B
8. A
9. C
10. A

MFG-D4

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-D4

Subject: **Manufacturing Technology** **Time: 8 Hrs.**

Duty: **Recognize Different Manufacturing Materials and Processes**
Task: Test Metal Samples for Hardness

Objective(s):

Upon completion of this unit the student will be able to:

a. Perform file test to test for metal hardness;
b. Use other tests to identify metals; and,
c. Perform Rockwell hardness tests.

Instructional Materials:

MASTER Handout (MFG-D4-HO)
MASTER Laboratory Exercise (MFG-D4-LE)
MASTER Laboratory Aid (MFG-D4-LA)
MASTER Self-Assessment
Several samples of various metals (including one aluminum and one magnesium)
Rockwell hardness tester
Grinder
New files (one per student)
Safety glasses or face shields (one per student)
Copper sulfate or zinc chloride solution

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Selection & Identification of Steels and Rockwell & Brinell Hardness Testers"

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-D1 "Identify Materials with Desired Properties"
MFG-D2 "Identify Materials and Processes to Produce a Part"
MFG-D3 "Describe the Heat Treating Process"

Introduction:

Hardness is surface resistance to deformation. It is not tensile strength; although a mathematical relationship between the two is relevant to machining and metal working in general.

Presentation Outline:

I. Perform File Test to Test for Metal Hardness
    A. Imprecise method, good for rough estimates only
    B. Requires more experienced machinist
II. Use Other Tests to Identify Metals
    A. High-carbon steels show more spark bursts than do low-carbon steels.
    B. Non-ferrous metals
        1. Aluminum
        2. Magnesium
        3. Brass
        4. Bronze
        5. Nickel
        6. Tin
        7. Others
III. Perform Rockwell Hardness Tests
    A. Ferrous metals
    B. Non-ferrous metals
IV. Perform Brinell Hardness Tests
    A. Ferrous metals
    B. Non-ferrous metals
V. Other Hardness Tests as Specified by the Instructor
    A. Ferrous metals
    B. Non-ferrous metals

Practical Application:

The student will complete the laboratory assignment (MFG-D4-LE).

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-D5) dealing with different welding operations.

MFG-D4-HO
Test Metal Samples for Hardness
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Perform file test to test for metal hardness;
b. Use other tests to identify metals; and,
c. Perform Rockwell hardness tests.

Module Outline:

I. Perform File Test to Test for Metal Hardness
    A. Imprecise method, good for rough estimates only
    B. Requires more experienced machinist
II. Use Other Tests to Identify Metals
    A. High-carbon steels show more spark bursts than do low-carbon steels.
    B. Non-ferrous metals
        1. Aluminum
        2. Magnesium
        3. Brass
        4. Bronze
        5. Nickel
        6. Tin
        7. Others
III. Perform Rockwell Hardness Tests
    A. Ferrous metals
    B. Non-ferrous metals
IV. Perform Brinell Hardness Tests
    A. Ferrous metals
    B. Non-ferrous metals
V. Other Hardness Tests as Specified by the Instructor
    A. Ferrous metals
    B. Non-ferrous metals

MFG-D4-LE
Test Metal Samples for Hardness
Attachment 2: MASTER Laboratory Exercise

I. The instructor should demonstrate the aluminum/magnesium test using the zinc chloride solution.
II. Each student should receive eye or full face protection and three to five samples for evaluation.
III. Each sample should be file-tested.
IV. Each sample should be spark-tested.
V. Each sample should be tested for hardness on the Rockwell tester.

RESULTS OF TESTS

Record your answers on the following charts. Under "Characteristics," write what you saw (spark length, color, etc.) or felt (resistance, heating, etc.) during the test.

FILE TEST

Sample	Characteristics	Preliminary Identification
1		
2		
3		
4		
5		

SPARK TEST

Sample	Characteristics	Preliminary Identification
1		
2		
3		
4		
5		

ROCKWELL HARDNESS TEST

Sample	Rockwell Hardness Number	Preliminary Identification
1		
2		
3		
4		
5		

BRINELL HARDNESS TEST

Sample	Brinell Hardness Number	Preliminary Identification
1		
2		
3		
4		
5		

OTHER HARDNESS TEST

Sample	Hardness Designation	Preliminary Identification
1		
2		
3		
4		
5		

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name________________________ Date______________

MFG-D4
Test Metal Samples for Hardness
Self-Assessment

Circle the letter preceding the correct answer.

1. The *hardness* of a metal is its ability to resist:
   A. Permanent deformation.
   B. Oxidation.
   C. Chemical reaction.
   D. All of the above answers are forms of hardness.
   E. None of the above answers is correct.

2. Rockwell testing machines test the sample metal's resistance to:
   A. Abrasion.
   B. Penetration.
   C. Elastic deformation.
   D. Electricity.
   E. None of the above answers is correct.

3. Materials such as nitrided steel and hard cast irons generally have Rockwell hardness numbers in excess of:
   A. B-50.
   B. B-75.
   C. B-100.
   D. B-150.
   E. None of the above answers is correct.

4. During the file test, if the file will mark the metal but not cut into it, then the metal should be treated as:
   A. High-alloy steel.
   B. Mild steel.
   C. Hardened tool steel.
   D. Medium-carbon steel.
   E. None of the above answers is correct.

5. Probably the best use of the spark test is to:
   A. Determine the alloy content of the sample.
   B. Identify cast iron.
   C. Compare the sample to a known piece.
   D. All of the above answers are valid.
   E. None of the above answers is correct.

6. Tool steel has a Rockwell hardness of ___, while hardened tool steel has hardness number of ___.
   A. C-42. . .C-64
   B. C-42. . .B-65
   C. C-64. . .C-42
   D. B-65. . .C-42
   E. None of the above answers is correct.

7. Which of the following surfaces should be avoided when hardness testing?
   A. Curved
   B. Rough
   C. Decarburized
   D. All of the above surfaces should be modified before testing the sample's hardness.
   E. None of the above answers is correct.

8. For hardness testing, the minimum recommended clearance from the edge is:
   A. ½"
   B. 1/4"
   C. 1/8"
   D. 1/16"
   E. None of the above answers is correct.

9. If a Rockwell tester is in daily use, it should be calibrated:
   A. Annually.
   B. Monthly.
   C. Weekly.
   D. Daily.
   E. Never.

10. Technician A says that, for large samples, multiple hardness test should be made and their results averaged. Technician B says that many materials vary in hardness over the length of the sample. Who is correct?
    A. Technician A only
    B. Technician B only
    C. Both technicians are correct.
    D. Neither technician is correct.

MFG-D4
Test Metal Samples for Hardness
Self-Assessment Answer Key

1. A

2. B

3. C

4. C

5. C

6. E

7. D

8. C

9. D

10. D

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-D5

Subject: **Manufacturing Technology** **Time: 20 Hrs.**

Duty: **Recognize Different Manufacturing Materials and Processes**
Task: Understand Welding Operations

Objective(s):

Upon completion of this unit the student will be able to:
a. Perform the basic SMAW process;
b. Perform the basic oxyacetylene cutting and welding process;
c. Perform the basic GTAW (Heliarc) process; and,
d. Perform the basic GMAW (MIG) process.

Instructional Materials:

MASTER Handout (MFG-D5-HO)
MASTER Laboratory Exercise (MFG-D5-LE)
MASTER Laboratory Aid (MFG-D5-LA)
MASTER Self-Assessment
Basic hand tools
Chipping hammer
Clear welding lens
Constant-current welding machine
Ground cable and clamp
Metal samples for cutting and welding
Safety glasses
Various small welders
Welding gloves
Welding helmet
Welding lens (#7 - 14)
Wire brush

References:

Oxy-Acetylene Handbook, Linde, Union Carbide Publisher, Latest Edition
New Lessons in Arc Welding, Lincoln Electric, Lincoln Electric Publishers, Latest Edition

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-D1	"Identify Materials with Desired Properties"
MFG-D2	"Identify Materials and Processes to Produce a Part"
MFG-D3	"Describe the Heat Treating Process"
MFG-D4	"Test Metal Samples for Hardness"

Introduction:

Welding is an important, if dangerous, part of the machinist's life. Welding operations are used to cut, repair, and fabricate almost daily. Proper use of the welding torch and its accompanying safety equipment is critical to the machining industry.

Presentation Outline:

DON'T CARRY A BOMB IN YOUR POCKET!

NEVER carry a butane lighter into a welding area. These are mini-Molotov cocktails.

I. Safety Procedures Specific to the Welding Process
   A. Specific safety precautions must be taken to ensure a proper breathing atmosphere in all welding areas.
      1. Weld only in ventilated areas. Welding shielding gases can displace the air needed for breathing. These gases are odorless and colorless, and most are heavier than air.
      2. Weld in a position that will allow your head to be out of the welding plume, but will still give a good view of the welding arc. The welding plume could contain harmful fumes and gases.
      3. Provide enough ventilation wherever welding and cutting are performed. Welding in confined spaces may require special procedures, such as the use of an air-supplied hood or hose mask.
      4. Do not weld on dirty plate or plate contaminated with an unknown material. The fumes and gases which are formed could be hazardous to health.
   B. Electrical shock can be avoided by following specific safety precautions.
      1. Do not touch live electrical parts.
      2. Ground all electrical equipment and the work-piece to prevent accidental electrical shocks.
      3. Use the correct welding cable size for both the ground lead and the welding lead. Sustained overloading will cause cable failure and result in possible electrical shock or fire hazard.

    4. Be sure all electrical connections are tight, clean, and dry. Poor electrical connections can heat up and even melt, causing dangerous arcs and sparks.
    5. Keep dry. Moisture and water can conduct electricity. Fix water leaks immediately.
    6. Keep welding cables and connectors in good condition. Improper or worn electrical connections can cause short circuits and can increase the chance of an electrical shock.
    7. Avoid open-circuit voltage. Open-circuit voltage is much higher than welding voltage.
    8. Shut off electrical power when working on welding equipment.

C. Ultraviolet and infrared rays emitted by the welding arc, as well as the spatter from the welding arc, can injure eyes and burn skin. Specific safety precautions must be followed to ensure adequate protection.
    1. Wear 100% cotton clothing. It will not catch fire easily, it offers good protection from light welding spatter, and it is cooler in the summer and warmer in the winter.
    2. Cover all skin surfaces. Keep shirt sleeves rolled down.
    3. Wear cuffless pants to eliminate spatter traps.
    4. Wear leather boots. Pant legs should cover boot tops.
    5. Wear clean clothing. Oil- and grease-stained clothes will tend to ignite from welding spatter.
    6. For more severe welding conditions, wear protective clothing such as heat resistant jackets, aprons, and leggings.
    7. Wear safety glasses to protect from arc flashes, mechanical injury, or other mishaps.
    8. Wear ear protection, not only where there is noise but where there is a chance that spatter or sparks could get into the ears.
    9. Wear a 100% cotton cap to protect the head from sparks or spatter.
    10. Wear long-gauntlet leather gloves.
    11. Do not touch hot metal with bare hands. Use tongs or pliers and wear leather gloves.
    12. Protect nearby workers from exposure to the welding arc by putting up shields.
    13. Wear a welding helmet with the correct shade of welding lens. Choose the correct lens from a filter recommendations table (See Figure 1).

FILTER RECOMMENDATIONS
(adapted from ANSI Safety Standard Z49.1-88)
SMAW

Application	Minimum Shade No.	Suggested Shade*
Less than 60 amps	7	9
60 to 160 amps	8	10
160 to 250 amps	10	12
250 to 500 amps	11	14

* As a general rule, start with a shade that is too dark to see the arc zone. Then go to the next lighter shade until you find one which gives you sufficient view of the arc zone without exerting a strain on your eyes.

FIGURE 1 FILTER RECOMMENDATIONS

D. Specific precautions must be taken to ensure that there is no loss of property due to welding sparks, spatter, and heat.
   1. If possible, weld in specially designated areas or enclosures of noncombustible construction.
   2. Remove combustibles from the work area by at least 35 feet if possible.
   3. Cover combustibles that cannot be removed from the welding area with tight-fitting, flame-resistant material. Items that should be covered include combustible walls, floors, ceilings, and any cracks or other openings that might let a spark pass through it.
   4. If welding is to be performed on or adjacent to a metal wall, ceiling, or partition, move combustibles on the other side to a safe location.
   5. If combustibles cannot be adequately sealed off or removed, station a fire watcher at that location. The fire watcher must have adequate fire extinguishing capabilities.
   6. Do not weld on materials having either a coating or internal structure that is combustible.
   7. Place hot scrap and slag in non-combustible containers.
   8. Ensure that fire extinguishers are available nearby.

9. Conduct a thorough examination for evidence of a fire before leaving the work area, and continue a fire check for at least 30 minutes after the welding operation has been completed.
10. Follow all company safety procedures regarding welding in hazardous areas.

E. Specific Safety Precautions for Oxyacetylene Equipment

CAUTION: Specific preventive and protective safety measures must be followed when using oxyacetylene equipment:

1. Use goggles or shield with a number five shade.
2. Wear gloves, long sleeve shirts, pants of high cotton or wool content, leather boots, and soft cotton caps.
3. When lighting the torch, direct the torch away from yourself and other personnel.
4. Never leave a lit torch unattended. When leaving your work station, always extinguish your torch.
5. Never use matches or butane lighters for lighting a torch. Only use spark or friction lighters.
6. Never cut on containers that have contained flammable or toxic substances.
7. Either move work away from or protect wooden or other flammable materials which may be close to the work.
8. When cutting, cover concrete floors with sheet metal where sparks and molten metal are being directed.
9. Before beginning to work, locate the nearest fire alarm and the nearest fire extinguisher.
10. Cut in a well-ventilated area. If adequate ventilation is not possible, use a respirator.
11. Keep all petroleum products away from oxyacetylene equipment and operations. The combination of pure oxygen and oil is explosive.

F. Specific Safety Precautions for Acetylene and Oxygen Cylinders

CAUTION: Handle acetylene and oxygen cylinders carefully:

1. Keep acetylene operating pressures at or below 15 psi.
2. Open the acetylene cylinder valve one-half to one full turn when using a portable rig to be sure that the cylinder can be quickly turned off in the event of burn-back or a fire at a leak in the hose or at a connection.
3. Do not open the acetylene torch valve where acetylene could flow into a bucket or other container and cause a fire.
4. Never attempt to connect an acetylene hose to an oxygen torch connection. Damage to the torch or an explosion could result. Acetylene hoses are colored red and acetylene fittings are left-hand threaded and usually notched.
5. Never use oxygen or fuel gas from a cylinder except through an approved pressure-reducing regulator.

6. Do not use pipe-fitting compounds or thread lubricants for making connections.
7. Never use a cylinder that is leaking.
8. Store and transport cylinders in the upright position.
9. Secure all cylinders with chain when storing, transporting, or using, to prevent them from being turned over by accident.
10. Never tamper with fusible plugs or other safety devices on cylinders.
11. To open and close acetylene cylinder valves not provided with hand-wheels, always use the special wrench or key. When cutting, leave the key in place for rapid shutdown in case of fire.
12. Never use any cylinder, full or empty, as a roller or support.
13. Never use oxygen as though it were compressed air.
14. Do not handle oxygen cylinders on the same platform with oil.
15. Never use wire-rope slings or electromagnets for lifting cylinders. Do not lift cylinders by the protective cap alone.
16. Store oxygen cylinders separately from fuel gas cylinders.
17. Always keep empty cylinders separate from full cylinders.
18. Mark all empty cylinders as such after use.
19. Keep all cylinders stored inside buildings at least 20 feet away from combustible materials.
20. Never bring any arc or flame close to or directly into contact with a cylinder.
21. Never exceed the maximum safe withdrawal rate for acetylene cylinders (one seventh of the cylinder's *current* contents per hour). If acetylene is withdrawn from the cylinder at a greater rate, acetone will also be withdrawn from the cylinder, damaging the cutting equipment. If additional flow is needed, then manifold the required number of cylinders together.

G. Specific Safety Precautions for Regulator Burnout (R.B.O.)

CAUTION: Avoid potentially deadly regulator burnout (R.B.O.). Regulator burnout is a spontaneous explosion that happens when a torch is being lit. To minimize the risk of R.B.O., follow these safety precautions:

1. "Crack" the oxygen cylinder valve (open it slightly) before attaching the regulator. Stand to one side or the rear of the cylinder outlet. Open the cylinder valve slightly for an instant and then close it to clean the valve of dust and dirt which may have accumulated during storage. Dirt can damage an oxygen regulator and may cause R.B.O.
2. Use only oxygen regulators to control oxygen supply. A pressure-reducing regulator must be connected to the oxygen cylinder valve. Make certain the regulator is clean, free of grease and oil, and has a clean filter installed in its inlet nipple.

Oil, grease, coal dust, and other combustibles can cause regulator burnouts. Never use an oxygen regulator for other gases.

3. Before opening an oxygen cylinder valve, make sure the oxygen regulator pressure-adjusting screw is released. This is done by rotating the screw counterclockwise until it turns freely. This closes the regulator valve and prevents damage due to a sudden pressure surge.
4. While opening the oxygen cylinder valve, stand to one side of the oxygen regulator. Do not stand in line with the front or the back of the pressure-adjusting screw. Open the cylinder valve as slowly as possible, until the high pressure gauge reaches cylinder pressure. Never open a cylinder valve suddenly. Sudden surges of high pressure can cause R.B.O.

II. Describe the SMAW Process

Shielded Metal Arc Welding is a welding process which joins metals by heating them with an arc between a covered metal electrode and the metals being joined. Shielding is obtained from the decomposition (breakdown) of the electrode covering. Pressure is not used and filler metal is obtained from the electrode. The electric arc flowing across an air gap produces very intense heat and light. An electric arc has been measured at 10,000°F. Considering that steel melts at around 2800°F, the electric arc is indeed a very fast and efficient heat source for melting steel when welding.

III. Describe the Oxyacetylene Cutting and Welding Process

Oxyacetylene cutting requires the use of specific procedures and specific techniques in order to work safely and to produce acceptable cuts. Proper flame adjustments, torch angles, and flame-to-work distances must be maintained in order to produce good cuts. Oxyacetylene cutting can be done from both fixed cutting stations and from portable cutting stations.

The key operations to oxyacetylene cutting are as follows:

1. Prepare to cut.
2. Light the torch.
3. Cut metal with the torch.
4. Extinguish the torch.

HOW TO SELECT THE CORRECT NUMBER OF ACETYLENE CYLINDERS

To determine the number of cylinders required for proper manifold operation, follow the guidelines below:

1. The number of cylinders in the manifold is determined by the volume of gas in cubic feet per hour required. Determine the cubic feet per hour required for the largest tip used and multiply that by the number of torches or stations in operation at the same time. This will give the total volume of each gas required per hour.
2. The manifold should have enough cylinders to provide a minimum of one day's requirements.
3. Maximum acetylene withdrawal for continuous operation is 1/7 (of 14%) of each cylinder capacity per hour. The chart allows for 7.8% excess capacity.

CFH acetylene withdrawal per hour required	Number of 300 cubic foot cylinders per manifold
40	1
80	2
120	3
160	4
200	5
240	6
280	7
320	8
360	9
400	10
440	11
480	12
520	13
560	14
600	15
640	16
680	17
720	18
760	19
800	20

Acetylene Cylinder Manifold Guide

IV. Describe the GTAW (Heliarc) Process
V. Describe the GMAW (MIG) Process
VI. Describe the Band/Flash Welding Machine and Process

Practical Application:

The student will be able to perform minor welding repairs.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-E1) dealing with understanding metrology terms.

MFG-D5-HO
Understand Welding Operations
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Perform the basic SMAW process;
b. Perform the basic oxyacetylene cutting and welding process;
c. Perform the basic GTAW (Heliarc) process; and,
d. Perform the basic GMAW (MIG) process.

Module Outline:

DON'T CARRY A BOMB IN YOUR POCKET!

NEVER carry a butane lighter into a welding area. These are mini-Molotov cocktails.

I. Safety Procedures Specific to the Welding Process
   A. Specific safety precautions must be taken to ensure a proper breathing atmosphere in all welding areas.
      1. Weld only in ventilated areas. Welding shielding gases can displace the air needed for breathing. These gases are odorless and colorless, and most are heavier than air.
      2. Weld in a position that will allow your head to be out of the welding plume, but will still give a good view of the welding arc. The welding plume could contain harmful fumes and gases.
      3. Provide enough ventilation wherever welding and cutting are performed. Welding in confined spaces may require special procedures, such as the use of an air-supplied hood or hose mask.
      4. Do not weld on dirty plate or plate contaminated with an unknown material. The fumes and gases which are formed could be hazardous to health.
   B. Electrical shock can be avoided by following specific safety precautions.
      1. Do not touch live electrical parts.
      2. Ground all electrical equipment and the work-piece to prevent accidental electrical shocks.
      3. Use the correct welding cable size for both the ground lead and the welding lead. Sustained overloading will cause cable failure and result in possible electrical shock or fire hazard.

4. Be sure all electrical connections are tight, clean, and dry. Poor electrical connections can heat up and even melt, causing dangerous arcs and sparks.
5. Keep dry. Moisture and water can conduct electricity. Fix water leaks immediately.
6. Keep welding cables and connectors in good condition. Improper or worn electrical connections can cause short circuits and can increase the chance of an electrical shock.
7. Avoid open-circuit voltage. Open-circuit voltage is much higher than welding voltage.
8. Shut off electrical power when working on welding equipment.

C. Ultraviolet and infrared rays emitted by the welding arc, as well as the spatter from the welding arc, can injure eyes and burn skin. Specific safety precautions must be followed to ensure adequate protection.

1. Wear 100% cotton clothing. It will not catch fire easily, it offers good protection from light welding spatter, and it is cooler in the summer and warmer in the winter.
2. Cover all skin surfaces. Keep shirt sleeves rolled down.
3. Wear cuffless pants to eliminate spatter traps.
4. Wear leather boots. Pant legs should cover boot tops.
5. Wear clean clothing. Oil- and grease-stained clothes will tend to ignite from welding spatter.
6. For more severe welding conditions, wear protective clothing such as heat resistant jackets, aprons, and leggings.
7. Wear safety glasses to protect from arc flashes, mechanical injury, or other mishaps.
8. Wear ear protection, not only where there is noise but where there is a chance that spatter or sparks could get into the ears.
9. Wear a 100% cotton cap to protect the head from sparks or spatter.
10. Wear long-gauntlet leather gloves.
11. Do not touch hot metal with bare hands. Use tongs or pliers and wear leather gloves.
12. Protect nearby workers from exposure to the welding arc by putting up shields.
13. Wear a welding helmet with the correct shade of welding lens. Choose the correct lens from a filter recommendations table (See Figure 1).

FILTER RECOMMENDATIONS
(adapted from ANSI Safety Standard Z49.1-88)
SMAW

Application	Minimum Shade No.	Suggested Shade*
Less than 60 amps	7	9
60 to 160 amps	8	10
160 to 250 amps	10	12
250 to 500 amps	11	14

* As a general rule, start with a shade that is too dark to see the arc zone. Then go to the next lighter shade until you find one which gives you sufficient view of the arc zone without exerting a strain on your eyes.

FIGURE 1 FILTER RECOMMENDATIONS

D. Specific precautions must be taken to ensure that there is no loss of property due to welding sparks, spatter, and heat.
   1. If possible, weld in specially designated areas or enclosures of noncombustible construction.
   2. Remove combustibles from the work area by at least 35 feet if possible.
   3. Cover combustibles that cannot be removed from the welding area with tight-fitting, flame-resistant material. Items that should be covered include combustible walls, floors, ceilings, and any cracks or other openings that might let a spark pass through it.
   4. If welding is to be performed on or adjacent to a metal wall, ceiling, or partition, move combustibles on the other side to a safe location.
   5. If combustibles cannot be adequately sealed off or removed, station a fire watcher at that location. The fire watcher must have adequate fire extinguishing capabilities.
   6. Do not weld on materials having either a coating or internal structure that is combustible.
   7. Place hot scrap and slag in non-combustible containers.
   8. Ensure that fire extinguishers are available nearby.

    9. Conduct a thorough examination for evidence of a fire before leaving the work area, and continue a fire check for at least 30 minutes after the welding operation has been completed.
    10. Follow all company safety procedures regarding welding in hazardous areas.

E. Specific Safety Precautions for Oxyacetylene Equipment

CAUTION: Specific preventive and protective safety measures must be followed when using oxyacetylene equipment:

1. Use goggles or shield with a number five shade.
2. Wear gloves, long sleeve shirts, pants of high cotton or wool content, leather boots, and soft cotton caps.
3. When lighting the torch, direct the torch away from yourself and other personnel.
4. Never leave a lit torch unattended. When leaving your work station, always extinguish your torch.
5. Never use matches or butane lighters for lighting a torch. Only use spark or friction lighters.
6. Never cut on containers that have contained flammable or toxic substances.
7. Either move work away from or protect wooden or other flammable materials which may be close to the work.
8. When cutting, cover concrete floors with sheet metal where sparks and molten metal are being directed.
9. Before beginning to work, locate the nearest fire alarm and the nearest fire extinguisher.
10. Cut in a well-ventilated area. If adequate ventilation is not possible, use a respirator.
11. Keep all petroleum products away from oxyacetylene equipment and operations. The combination of pure oxygen and oil is explosive.

F. Specific Safety Precautions for Acetylene and Oxygen Cylinders

CAUTION: Handle acetylene and oxygen cylinders carefully:

1. Keep acetylene operating pressures at or below 15 psi.
2. Open the acetylene cylinder valve one-half to one full turn when using a portable rig to be sure that the cylinder can be quickly turned off in the event of burn-back or a fire at a leak in the hose or at a connection.
3. Do not open the acetylene torch valve where acetylene could flow into a bucket or other container and cause a fire.
4. Never attempt to connect an acetylene hose to an oxygen torch connection. Damage to the torch or an explosion could result. Acetylene hoses are colored red and acetylene fittings are left-hand threaded and usually notched.
5. Never use oxygen or fuel gas from a cylinder except through an approved pressure-reducing regulator.

6. Do not use pipe-fitting compounds or thread lubricants for making connections.
7. Never use a cylinder that is leaking.
8. Store and transport cylinders in the upright position.
9. Secure all cylinders with chain when storing, transporting, or using, to prevent them from being turned over by accident.
10. Never tamper with fusible plugs or other safety devices on cylinders.
11. To open and close acetylene cylinder valves not provided with hand-wheels, always use the special wrench or key. When cutting, leave the key in place for rapid shutdown in case of fire.
12. Never use any cylinder, full or empty, as a roller or support.
13. Never use oxygen as though it were compressed air.
14. Do not handle oxygen cylinders on the same platform with oil.
15. Never use wire-rope slings or electromagnets for lifting cylinders. Do not lift cylinders by the protective cap alone.
16. Store oxygen cylinders separately from fuel gas cylinders.
17. Always keep empty cylinders separate from full cylinders.
18. Mark all empty cylinders as such after use.
19. Keep all cylinders stored inside buildings at least 20 feet away from combustible materials.
20. Never bring any arc or flame close to or directly into contact with a cylinder.
21. Never exceed the maximum safe withdrawal rate for acetylene cylinders (one seventh of the cylinder's *current* contents per hour). If acetylene is withdrawn from the cylinder at a greater rate, acetone will also be withdrawn from the cylinder, damaging the cutting equipment. If additional flow is needed, then manifold the required number of cylinders together.

G. Specific Safety Precautions for Regulator Burnout (R.B.O.)

CAUTION: Avoid potentially deadly regulator burnout (R.B.O.). Regulator burnout is a spontaneous explosion that happens when a torch is being lit. To minimize the risk of R.B.O., follow these safety precautions:

1. “Crack” the oxygen cylinder valve (open it slightly) before attaching the regulator. Stand to one side or the rear of the cylinder outlet. Open the cylinder valve slightly for an instant and then close it to clean the valve of dust and dirt which may have accumulated during storage. Dirt can damage an oxygen regulator and may cause R.B.O.
2. Use only oxygen regulators to control oxygen supply. A pressure-reducing regulator must be connected to the oxygen cylinder valve. Make certain the regulator is clean, free of grease and oil, and has a clean filter installed in its inlet nipple.

Oil, grease, coal dust, and other combustibles can cause regulator burnouts. Never use an oxygen regulator for other gases.

3. Before opening an oxygen cylinder valve, make sure the oxygen regulator pressure-adjusting screw is released. This is done by rotating the screw counterclockwise until it turns freely. This closes the regulator valve and prevents damage due to a sudden pressure surge.
4. While opening the oxygen cylinder valve, stand to one side of the oxygen regulator. Do not stand in line with the front or the back of the pressure-adjusting screw. Open the cylinder valve as slowly as possible, until the high pressure gauge reaches cylinder pressure. Never open a cylinder valve suddenly. Sudden surges of high pressure can cause R.B.O.

II. Describe the SMAW Process

Shielded Metal Arc Welding is a welding process which joins metals by heating them with an arc between a covered metal electrode and the metals being joined. Shielding is obtained from the decomposition (breakdown) of the electrode covering. Pressure is not used and filler metal is obtained from the electrode. The electric arc flowing across an air gap produces very intense heat and light. An electric arc has been measured at 10,000°F. Considering that steel melts at around 2800°F, the electric arc is indeed a very fast and efficient heat source for melting steel when welding.

III. Describe the Oxyacetylene Cutting and Welding Process

Oxyacetylene cutting requires the use of specific procedures and specific techniques in order to work safely and to produce acceptable cuts. Proper flame adjustments, torch angles, and flame-to-work distances must be maintained in order to produce good cuts. Oxyacetylene cutting can be done from both fixed cutting stations and from portable cutting stations.

The key operations to oxyacetylene cutting are as follows:

1. Prepare to cut.
2. Light the torch.
3. Cut metal with the torch.
4. Extinguish the torch.

HOW TO SELECT THE CORRECT NUMBER OF ACETYLENE CYLINDERS

To determine the number of cylinders required for proper manifold operation, follow the guidelines below:

1. The number of cylinders in the manifold is determined by the volume of gas in cubic feet per hour required. Determine the cubic feet per hour required for the largest tip used and multiply that by the number of torches or stations in operation at the same time. This will give the total volume of each gas required per hour.
2. The manifold should have enough cylinders to provide a minimum of one day's requirements.
3. Maximum acetylene withdrawal for continuous operation is 1/7 (of 14%) of each cylinder capacity per hour. The chart allows for 7.8% excess capacity.

CFH acetylene withdrawal per hour required	Number of 300 cubic foot cylinders per manifold
40	1
80	2
120	3
160	4
200	5
240	6
280	7
320	8
360	9
400	10
440	11
480	12
520	13
560	14
600	15
640	16
680	17
720	18
760	19
800	20

Acetylene Cylinder Manifold Guide

IV. Describe the GTAW (Heliarc) Process

V. Describe the GMAW (MIG) Process

VI. Describe the Band/Flash Welding Machine and Process

MFG-D5-LE
Understand Welding Operations
Attachment 2: **MASTER** Laboratory Exercise

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1. The instructor will demonstrate each of the following processes:
   a. Basic SMAW process;
   b. Basic oxyacetylene cutting and welding process;
   c. Basic GTAW (Heliarc) process; and,
   d. Basic GMAW (MIG) process.

2. The students will practice each of the following processes:
   a. Basic SMAW process;
   b. Basic oxyacetylene cutting and welding process;
   c. Basic GTAW (Heliarc) process; and,
   d. Basic GMAW (MIG) process.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name____________________________ Date________________

MFG-D5
Understand Welding Operations
Self-Assessment

Circle the letter preceding the correct answer.

1. Technician A says that they can cut into an old water can with the torch. Technician B says that containers of flammable or toxic substances should never be cut with a torch. Who is correct?
    A. Technician A only
    B. Technician B only
    C. Both Technicians A and B
    D. Neither Technician A nor B

2. Before attaching the regulators to the cylinder valves:
    A. Clean the nipples with acetone.
    B. Crack the valves to blow out any dirt.
    C. Lubricate the threads with oil.
    D. All of the above
    E. None of the above

3. Technician A says that since B is left-handed, B should cut from left to right. Technician B says that the pre-heat flame should still be from 1/6" to ⅛" from the base metal, regardless of the direction of travel. Who is correct?
    A. Technician A only
    B. Technician B only
    C. Both Technicians A and B
    D. Neither Technician A nor B

4. If adequate ventilation is unavailable, the technician should:
    A. Cut the metal anyway; ventilation is not important.
    B. Cut the metal while wearing a respirator.
    C. Cut the metal while wearing a heavy-duty dust mask.
    D. Refuse to make the cut.

5. Technician A says that they must reduce the acetylene flow until the flame just starts to produce black smoke around its edges. Technician B says that the acetylene flow must then be increased until the smoke disappears. Who is correct?
    A. Technician A only
    B. Technician B only
    C. Both Technicians A and B
    D. Neither Technician A nor B

6. Acetylene operating pressures must be kept at or below:
   A. 5 psi
   B. 15 psi
   C. 25 psi
   D. Acetylene operating pressures are immaterial.

7. Dirty orifices on the cutting tip can produce:
   A. Wide kerfs.
   B. Adherent slag.
   C. Rough cut appearance.
   D. All of the above.
   E. None of the above

8. Acetylene hoses are ___; acetylene fittings are ___.
   A. Red . . . left-handed
   B. Blue . . . left-handed
   C. Red . . . right-handed
   D. Blue . . . left-handed

9. Technician A says that, for cutting holes, the torch must be held parallel to the base metal throughout the cut. Technician B says that square cuts require the torch to be held at 45° to the base metal. Who is correct?
   A. Technician A only
   B. Technician B only
   C. Both Technicians A and B
   D. Neither Technician A nor B

10. Lag lines are the result of:
    A. Correct travel speed.
    B. Too great a travel speed.
    C. Too slow a travel speed.
    D. Incorrect torch angle.
    E. None of the above

11. All cylinders should be secured except when:
    A. Transporting them.
    B. Storing them.
    C. Using them.
    D. Always secure cylinders with chains or in permanent racks.
    E. Securing cylinders is unnecessary.

12. Technician A says that the acetylene cylinder's valve should be opened all the way. Technician B says that the oxygen cylinder's valve should be opened no more than one full turn. Who is correct?
    A. Technician A only
    B. Technician B only
    C. Both Technicians A and B
    D. Neither Technician A nor B

13. Which of the following can be used to ignite an oxyacetylene torch?
    A. Matches
    B. A cigarette lighter
    C. A spark or friction lighter
    D. Any of the above
    E. None of the above

14. Both acetylene and oxygen lines should be ___ when closing down the work station.
    A. Removed
    B. Cleaned with acetone
    C. Bled free of gas or fuel
    D. All of the above

15. Technician A says that only oxygen-specific regulators can be used on oxygen cylinders. Technician B says that it is acceptable to use oxygen regulators on other gas cylinders. Who is correct?
    A. Technician A only
    B. Technician B only
    C. Both Technicians A and B
    D. Neither Technician A nor B

16. When extinguishing the torch, Technician A says that the acetylene torch valve should be closed first. Technician B says that the oxygen torch valve should be closed first. Who is correct?
    A. Technician A only
    B. Technician B only
    C. Both Technicians A and B
    D. Neither Technician A nor B

17. Good oxy-fuel cuts require an oxygen purity of at least:
    A. 99.5%.
    B. 95.9%.
    C. 59.9%.
    D. None of the above is correct.

18. Technician A says that oxygen cylinders should be stored well away from fuel gas cylinders. Technician B says that separate storage is unnecessary. Who is correct?
A. Technician A only
B. Technician B only
C. Both Technicians A and B
D. Neither Technician A nor B

19. The maximum safe withdrawal rate for acetylene cylinders is:
A. One fourth of current content per hour.
B. One fifth of current content per hour.
C. One seventh of current content per hour.
D. One tenth of current content per hour.

20. Which of the following *can* be cut with an oxy-acetylene torch?
A. Aluminum
B. Copper
C. Chromium
D. All of the above
E. None of the above

MFG-D5
Understand Welding Operations
Self-Assessment Answer Key

1.	C	11.	D
2.	B	12.	D
3.	C	13.	C
4.	B	14.	C
5.	C	15.	A
6.	B	16.	A
7.	D	17.	A
8.	A	18.	A
9.	D	19.	C
10.	B	20.	E

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module: MFG-D6

Subject: **Manufacturing Technology** **Time: 40 Hrs.**

Duty: **Recognize Different Manufacturing Materials and Processes**
Task: Evaluate Plastics, Composites and Other Manufacturing Processes

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Objective(s):

Upon completion of this module the student will be able to:

a. Demonstrate an understand terms related to the plastics industries: (e.g., classification, structure, manufacture, ingredients, available forms, and properties);

b. Identify common methods of processing plastics and composites, and describe in general terms how the processes work;

c. Discuss the powder metallurgy process (e.g., the processes involved in simple die compaction, the methods by which metal powders are produced, the metallurgical principles involved in bonding of powders in the sintering process, the advantages of several advanced powder metal processes, and the reasons for deciding to use powder metallurgy processes for manufacturing a part); and,

d. Discuss other nontraditional machining processes (e.g., electrical discharge machining (EDM), electrochemical machining (ECM), electrolytic grinding (ELG), LASER machining, ultrasonic machining, hydrojet machining, electron beam machining (EBM), and plasma technology) and describe in general terms how each of these processes work, and describe applications of the processes.

References:

Modern Materials and Manufacturing Processes, John E. Neeley & Richard R. Kibbe, Prentice Hall Career & Technology, Englewood Cliffs, NJ, Latest Edition

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Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-D1	"Identify Materials With Desired Properties"
MFG-D2	"Identify Materials and Processes to Produce a Part"
MFG-D3	"Describe the Heat Treating Process"
MFG-D4	"Test Metal Samples for Hardness"
MFG-D5	"Understand Welding Operations"

Introduction:

It would be difficult to envision the modern world without plastics and composites. The product line of these materials is vast and expanding every day. Some advantages include light weight, strength, resistance to rust and other corrosion, denting, chipping, changes in temperature, and ease of manufacturing. Plastic materials may be cast, molded, extruded, machined, fabricated, laminated, and rolled. Along with plastics there are many other types of non-traditional manufacturing processes which will be discussed during this lesson.

Presentation Outline:

- I. Discuss Plastics
  - A. Classifications of plastics
    - 1. Thermoplastics - These are plastics which become soft when exposed to heat and harden when cooled no matter how often the process is repeated. They can be reshaped many times by altering the heating and cooling. Important members of this group are acrylics, cellulosics, nylons, polystyrenes, polyethylenes, fluorocarbons, and vinyls.
    - 2. Thermosets - These plastics are set or cured into a permanent shape by heat and once set cannot be remelted and returned to their original state. Prominent members of this group of plastics are phenolics, aminos, polyesters, epoxies, and alkyds.
  - B. Plastic Structure
    - 1. In the formation of plastics, many atoms are combined to form molecules. Each atom is joined to the next by connecting links called valence bonds. Their structure is chain-like.
    - 2. In the thermoplastics, the atoms and molecules are joined end-to-end into a series of long chains, each chain independent of the others. When subjected to heat, this allows slipping of the chains, causing plastic flow.
    - 3. The structure of thermosets is also chain-like and, before molding, similar to that of thermoplastics. The curing or hardening process (usually during molding) consists of the formation of cross-links between adjacent molecules resulting in a complex, interconnected network. These cross-bonds prevent the slippage of individual chains, thus preventing plastic flow with the addition of heat.
  - C. How plastics are made
    - 1. Although plastics are synthetics, they are made from many common natural materials such as wood, air, water, petroleum, natural gas, and salt. These natural materials are broken apart

by separating their basic molecules and atoms. They are recombined in different ways with the aid of heat, pressure, and chemical action.

2. A simplified description of the manufacture of polystyrene illustrates the process. The raw materials used are coal and petroleum or natural gas. Benzene is extracted from the coal, and ethylene gas is obtained from the petroleum or the natural gas. The benzene and ethylene are then linked to form ethyl benzene. The last stage involves processing the ethyl benzene with heat and pressure and then milling and grinding it to form the final result, polystyrene.

D. Ingredients of plastics

1. Resin - Resin is a binder which serves to bind the plastic together and to impart some of the principal characteristics to the material. The resin determines whether the plastic is thermosetting or thermoplastic.
2. Filler - Before being processed into finished products, most plastics make use of a filler. Examples of fillers are wood flour and asbestos.
3. Solvent - A solvent is used to make the resin fluid so that the particles in plastics weld together. This is necessary because some resins are hard and brittle in their natural state.
4. Plasticizers - Plasticizers are used to lower viscosity at high processing temperatures and to impart plasticity to the final product.
5. Stabilizers - Stabilizers are often added to prevent degradation by heat, light and aging.
6. Colorants - Most plastics are not left in their natural color. Over 800 colorants are available to give the plastic products the desired color.

E. Available Forms

1. Molding Compounds - Some plastics are made into various solid forms which are convenient amounts of powder pressed together into larger discs to facilitate weighing and handling. Another similar form is called premix. This is usually a putty form of reinforcing fibers with polyester or epoxy resins.
2. Liquid Casting Resins - Many plastics, both thermoplastics and thermosetting, are available as liquids for casting and reinforcing. This liquid is often a two-part system with one part being a catalyst or curing agent for the other.
3. Solid Structural Shapes - Most plastics are further processed from molding compounds and liquid casting resins into sheets, rods and tubes of many dimensions, cross-sectional shapes, and surface finishes.

4. Coatings - Plastics have replaced many of the natural resins as constituents of finishes. Many quick-drying finishes are plastics.
5. Adhesives - In the field of adhesives, plastic resins have replaced many natural materials and have solved joining problems impossible for previous adhesives.
6. Expanded or Expandable - A number of plastics are available in expanded or expandable form. These are light in weight and appear to be full of bubbles or air spaces. A common rigid foam is made from polystyrene under the trade name of "Styrofoam."
7. Laminates - Laminate is a general term referring to a material made up of sheets or webs of paper, fabric, fibrous glass, or aluminum. This material is first impregnated or coated with a plastic resin and then bonded under heat and pressure to form sheets or panels or various types.
8. Fibers and Filaments - Some plastics are extruded into continuous filaments. As filaments, polystyrene is used as bristles for brooms, and nylon is the popular monofilament line for spinning-type fishing equipment.

F. Properties of plastics

1. Physical Properties - Most plastics are relatively light in weight. Some will float on water. The heaviest plastics are the fluorocarbons which are approximately 2.3 times heavier than water. Plastics are not very hard. The hardest types compare with brass and aluminum. Many plastics have tensile strengths varying from 5,000 to 10,000 psi. Most plastics will elongate several times their length before they will break. Plastics do not commonly expand and contract with the addition or loss of water as does wood. Plastics are particularly vibration absorbent, about ten times more so than steel.
2. Electrical Properties - Nearly all plastics, when dry, are excellent insulators. Some have been developed which retain their insulating values even after long emersion in water. Some plastics have been developed that will actually carry current. Oriented polyester films are often used as insulators in capacitors because of their high dielectric constant. Polyethylene and polystyrene have very low dissipation factors and cannot be heat sealed electronically; the cellulosics have a high power factor and are readily sealed in this manner. In an insulating material, the dissipation factor is the ratio of the total power loss in the material to the product of the voltage and current in a capacitor in which the material is the insulator.
3. Thermal Properties - Plastics fall in the group of heat insulators; this is, they have very low thermal conductivities. Copper transmit over 2000 times as much heat as most plastics. Plastics exhibit relatively high specific heats. Most plastics are

good thermal insulators, especially the foamed plastics. In general plastics are low in heat resistance. Plastics have good resistance to cold. The refrigeration industry makes extensive use of plastics.

4. Chemical Properties - Most plastics are extremely resistant to weak acids. The fluorocarbons are probably the most resistant of all plastic to the effects of acids. Most plastics are very resistant to weak alkalies, but only about half of them resist strong alkalies completely. Exceptional plastics in this respect are the styrenes, polyethylenes, and fluorocarbons. Most plastics are resistant to common vegetable and mineral oils and greases.

II. Discuss Plastic Molding Processes

- A. Blow molding - "air is used to force a mass of molten plastic against the sides of a mold shaped in the form of the desired end product."
- B. Vacuum forming - a vacuum is drawn on one side of the material and air pressure on the opposite side forces the material against the mold or form
- C. Injection molding - "molten plastic is forced into a metal die cavity that has been machined into the shape of the desired end product." When the plastic has solidified (cooled) the die is opened and the part is removed.
- D. Reaction injection molding (RIM) - two base resins are mixed together just as they enter the mold. A chemical reaction occurs at low heat and the plastic material of the end product is formed at that instant.
- E. Extrusion - plastic material is forced through an extrusion die that forms the end product.
- F. Compression molding - the plastic resin is in pellet or dry powder form and is mixed with a binder agent under pressure and then heated to give the part its final form. (This is normally used with thermoset plastics to make many common products to include handles and knobs for kitchen utensils.)
- G. Transfer molding - similar to above except that the resin is heated to a liquid state before being forced into the mold.
- H. Rotational molding - the mold cavity is spun and centrifugal force causes the resin to flow into the mold.

III. Discuss Composite - The Mechanical Properties of Plastic Can Be Greatly Enhanced by Adding a Reinforcing Agent to the Resin. Plastic Resins May Be Reinforced with Cloth, Paper, Glass Fibers, and Other Fibers Such as Graphite, Thus Forming *Advanced Composite Materials*.

- A. Discuss composite molding processes
  - 1. Fiber glassing - alternate layers of glass fibers fabric and resin are coated over a mold or form built in the shape of the finished product. (Examples: spas and boats.)

        2. Calendaring or rolling - "plastic is rolled thin to form sheets or film" which is bonded to other materials for protection or other purposes.
        3. Plastic materials mixed with paint and sprayed or brushed on products. (Example: polyurethane-based paints.)
        4. High-pressure lamination - (Example: plastic laminate bonded over wood base to form a molded top for a kitchen cabinet.) Note: composites differ from reinforced plastics in that the fiber structure is continuous throughout the structure. It is this particular structural design that gives the composite its superior mechanical properties.
    B. Discuss the advantages of composites
        1. Excellent strength-to-weight ratio
        2. Resistance to corrosion
        3. Resistance to impact
        4. Ability to be formed into complex shapes
    C. Discuss composite manufacturing methods
        1. Pulltrusion - the fiber portion is pulled or drawn through the liquid resin and then through a heated die that forms the desired shape (Example: structural members and tube.)
        2. Filament winding - the fiber is wound back and forth on a cylindrical form. After curing, the form is removed leaving the hollow composite product.
        3. Laminating - alternate layers of resin containing the structural fiber are rolled or spread over the surface of the mold.

IV. Discuss the Powder Metallurgy Process - Powder Metallurgy, Commonly Known as P/M, Is Essentially the Compression of Finely Divided Metal Powder into a Briquette of the Desired Shape. The Briquette Is Then Heated to Form a Metallurgical Bond Between the Metal Particles. Over Half the P/M Products Are Used in the *Transportation* Industry.
    A. How P/M parts are made. (Basic steps)
        1. Compacting (molding) - loose powder (or blend) is placed in a die and pressed into shape (called a green compact). (Usually there is a mixture of different metal powders.) The ejected parts are called "*briquettes*."
        2. *Sintering* - heated in the proper atmosphere to cause the powders to bond together.
        3. Secondary operations - sizing, machining, grinding, heat treating, deburring, plating, or impregnating with oil.
    B. Producing metal powders. (*Iron* is the most used powder.)
        1. Reduction of oxides - iron is heated to mush then crushed.
        2. Electrolysis - deposits on a electrical cathode (very pure).
        3. Atomization - heated metal is sprayed through a nozzle then ground to the desired fineness.

    4. Metal powders range in size from .0001" to .002".

  C. Compacting of powders - powders are pressed from both top and bottom in dies that form the powder into the desired shape. Since compaction is from top and bottom, the powders flow in the direction of compaction.
    1. Mechanical presses - rapid rate of production (50,000 parts per hr. at about 30 tons of pressure).
    2. Hydraulic presses - very high pressure (5,000 tons).

  D. Sintering - the green compact part is heated to 60 to 80 percent of its melting temperature. *Infiltration* - process in which the pores or voids of a sintered or unsintered compact are filled with a metal or alloy of a lower melting point.

  E. Secondary operations:
    1. Sizing
    2. Impregnation
    3. Plating
    4. Other machining or grinding operations

  F. Advantages of P/M products (See the textbook)

V. Discuss Other Nontraditional Machining Processes - The Design and Manufacturing Engineer, in the Continuing Search for Improvements in Designs, Both Stimulates Development of Alternate Materials Processing Methods and Takes Advantage of New Processes That Evolve Naturally Throughout Manufacturing Industries. This Chapter Deals with Many of the Newer, Nontraditional Machining Processes.

  A. Electrodischarge Machining (EDM) - removes material by an electrical spark erosion process. Metal is removed as the spark pulses and bursts towards the workpiece.
    1. This process takes place in a dielectric (nonconducting) oil bath. This fluid concentrates the spark and also flushes away the spark eroded workpiece material.
    2. EDM electrodes - usually made from metal or carbon (graphite) and shaped by molding, machining. Since the electrode "is also eroded away," usually a roughing and a finishing electrode will be used.
    3. Wire EDM - uses a slender wire as an electrode. Works much like a contour bandsaw.

  B. Electrochemical Machining (ECM) - a "reverse metal-plating" process in that chemicals are pumped onto the surface of the workpiece which erode into the surface of the part. This is used for *weight reduction*.

    The Process: After cleaning, the metal areas which are *not* to be chemically machined are coated with a "*maskant*" which is resistant to the chemical action.

C. Electrolytic Grinding (ELG) - an electrical conducting, metal grinding wheel forces nonconducting abrasive grains over the surface of the workpiece eroding material.

D. Laser machining - (LASER - Light Amplification by Stimulated Emission of Radiation) - the use of coherent laser light instead of a cutting tool. Used mostly for thin materials.

E. Ultrasonic machining - similar to sand blasting only high frequency sound is used as the motive force to propel abrasive particles against the workpiece.

F. Hydrojet machining - uses an extremely high pressure water jet. Sometimes an abrasive material is added to the water.

G. Electron Beam Machining (EBM) - this process uses a continuous beam of electrons to erode the material. This process must be carried on in a *vacuum* chamber with special shielding to protect personnel from X-ray radiation.

H. Plasma technology - plasma is created by "passing a gas through an electric arc." The gas is ionized by the are and an extremely high temperature is produced. These temperatures can be in excess of 40,000 degrees. This is many times hotter than an electrical arc or a flame.

Practical Application:

Evaluation and/or Verification:

Students should demonstrate a proficiency of 80% on the Self-Assessment found at the end of this module.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-E1) dealing with understanding metrology terms.

MFG-D6-HO
Evaluate Plastics, Composites and Other Manufacturing Processes
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to:

a. Demonstrate an understand terms related to the plastics industries: (e.g., classification, structure, manufacture, ingredients, available forms, and properties);

b. Identify common methods of processing plastics and composites, and describe in general terms how the processes work;

c. Discuss the powder metallurgy process (e.g., the processes involved in simple die compaction, the methods by which metal powders are produced, the metallurgical principles involved in bonding of powders in the sintering process, the advantages of several advanced powder metal processes, and the reasons for deciding to use powder metallurgy processes for manufacturing a part); and,

d. Discuss other nontraditional machining processes (e.g., electrical discharge machining (EDM), electrochemical machining (ECM), electrolytic grinding (ELG), LASER machining, ultrasonic machining, hydrojet machining, electron beam machining (EBM), and plasma technology) and describe in general terms how each of these processes work, and describe applications of the processes.

Module Outline:

I. Discuss Plastics
  A. Classifications of plastics
    1. Thermoplastics - These are plastics which become soft when exposed to heat and harden when cooled no matter how often the process is repeated. They can be reshaped many times by altering the heating and cooling. Important members of this group are acrylics, cellulosics, nylons, polystyrenes, polyethylenes, fluorocarbons, and vinyls.
    2. Thermosets - These plastics are set or cured into a permanent shape by heat and once set cannot be remelted and returned to their original state. Prominent members of this group of plastics are phenolics, aminos, polyesters, epoxies, and alkyds.
  B. Plastic Structure
    1. In the formation of plastics, many atoms are combined to form molecules. Each atom is joined to the next by connecting links called valence bonds. Their structure is chain-like.

    2. In the thermoplastics, the atoms and molecules are joined end-to-end into a series of long chains, each chain independent of the others. When subjected to heat, this allows slipping of the chains, causing plastic flow.
    3. The structure of thermosets is also chain-like and, before molding, similar to that of thermoplastics. The curing or hardening process (usually during molding) consists of the formation of cross-links between adjacent molecules resulting in a complex, interconnected network. These cross-bonds prevent the slippage of individual chains, thus preventing plastic flow with the addition of heat.

C. How plastics are made
    1. Although plastics are synthetics, they are made from many common natural materials such as wood, air, water, petroleum, natural gas, and salt. These natural materials are broken apart by separating their basic molecules and atoms. They are recombined in different ways with the aid of heat, pressure, and chemical action.
    2. A simplified description of the manufacture of polystyrene illustrates the process. The raw materials used are coal and petroleum or natural gas. Benzene is extracted from the coal, and ethylene gas is obtained from the petroleum or the natural gas. The benzene and ethylene are then linked to form ethyl benzene. The last stage involves processing the ethyl benzene with heat and pressure and then milling and grinding it to form the final result, polystyrene.

D. Ingredients of plastics
    1. Resin - Resin is a binder which serves to bind the plastic together and to impart some of the principal characteristics to the material. The resin determines whether the plastic is thermosetting or thermoplastic.
    2. Filler - Before being processed into finished products, most plastics make use of a filler. Examples of fillers are wood flour and asbestos.
    3. Solvent - A solvent is used to make the resin fluid so that the particles in plastics weld together. This is necessary because some resins are hard and brittle in their natural state.
    4. Plasticizers - Plasticizers are used to lower viscosity at high processing temperatures and to impart plasticity to the final product.
    5. Stabilizers - Stabilizers are often added to prevent degradation by heat, light and aging.
    6. Colorants - Most plastics are not left in their natural color. Over 800 colorants are available to give the plastic products the desired color.

E. Available Forms

1. Molding Compounds - Some plastics are made into various solid forms which are convenient amounts of powder pressed together into larger discs to facilitate weighing and handling. Another similar form is called premix. This is usually a putty form of reinforcing fibers with polyester or epoxy resins.
2. Liquid Casting Resins - Many plastics, both thermoplastics and thermosetting, are available as liquids for casting and reinforcing. This liquid is often a two-part system with one part being a catalyst or curing agent for the other.
3. Solid Structural Shapes - Most plastics are further processed from molding compounds and liquid casting resins into sheets, rods and tubes of many dimensions, cross-sectional shapes, and surface finishes.
4. Coatings - Plastics have replaced many of the natural resins as constituents of finishes. Many quick-drying finishes are plastics.
5. Adhesives - In the field of adhesives, plastic resins have replaced many natural materials and have solved joining problems impossible for previous adhesives.
6. Expanded or Expandable - A number of plastics are available in expanded or expandable form. These are light in weight and appear to be full of bubbles or air spaces. A common rigid foam is made from polystyrene under the trade name of "Styrofoam."
7. Laminates - Laminate is a general term referring to a material made up of sheets or webs of paper, fabric, fibrous glass, or aluminum. This material is first impregnated or coated with a plastic resin and then bonded under heat and pressure to form sheets or panels or various types.
8. Fibers and Filaments - Some plastics are extruded into continuous filaments. As filaments, polystyrene is used as bristles for brooms, and nylon is the popular monofilament line for spinning-type fishing equipment.

F. Properties of plastics

1. Physical Properties - Most plastics are relatively light in weight. Some will float on water. The heaviest plastics are the fluorocarbons which are approximately 2.3 times heavier than water. Plastics are not very hard. The hardest types compare with brass and aluminum. Many plastics have tensile strengths varying from 5,000 to 10,000 psi. Most plastics will elongate several times their length before they will break. Plastics do not commonly expand and contract with the addition or loss of water as does wood. Plastics are particularly vibration absorbent, about ten times more so than steel.
2. Electrical Properties - Nearly all plastics, when dry, are excellent insulators. Some have been developed which retain

their insulating values even after long emersion in water. Some plastics have been developed that will actually carry current. Oriented polyester films are often used as insulators in capacitors because of their high dielectric constant. Polyethylene and polystyrene have very low dissipation factors and cannot be heat sealed electronically; the cellulosics have a high power factor and are readily sealed in this manner. In an insulating material, the dissipation factor is the ratio of the total power loss in the material to the product of the voltage and current in a capacitor in which the material is the insulator.

3. Thermal Properties - Plastics fall in the group of heat insulators; this is, they have very low thermal conductivities. Copper transmit over 2000 times as much heat as most plastics. Plastics exhibit relatively high specific heats. Most plastics are good thermal insulators, especially the foamed plastics. In general plastics are low in heat resistance. Plastics have good resistance to cold. The refrigeration industry makes extensive use of plastics.
4. Chemical Properties - Most plastics are extremely resistant to weak acids. The fluorocarbons are probably the most resistant of all plastic to the effects of acids. Most plastics are very resistant to weak alkalies, but only about half of them resist strong alkalies completely. Exceptional plastics in this respect are the styrenes, polyethylenes, and fluorocarbons. Most plastics are resistant to common vegetable and mineral oils and greases.

II. Discuss Plastic Molding Processes

- A. Blow molding - "air is used to force a mass of molten plastic against the sides of a mold shaped in the form of the desired end product."
- B. Vacuum forming - a vacuum is drawn on one side of the material and air pressure on the opposite side forces the material against the mold or form
- C. Injection molding - "molten plastic is forced into a metal die cavity that has been machined into the shape of the desired end product." When the plastic has solidified (cooled) the die is opened and the part is removed.
- D. Reaction injection molding (RIM) - two base resins are mixed together just as they enter the mold. A chemical reaction occurs at low heat and the plastic material of the end product is formed at that instant.
- E. Extrusion - plastic material is forced through an extrusion die that forms the end product.
- F. Compression molding - the plastic resin is in pellet or dry powder form and is mixed with a binder agent under pressure and then heated to give the part its final form. (This is normally used with thermoset plastics to make many common products to include handles and knobs for kitchen utensils.)

G. Transfer molding - similar to above except that the resin is heated to a liquid state before being forced into the mold.

H. Rotational molding - the mold cavity is spun and centrifugal force causes the resin to flow into the mold.

III. Discuss Composite - The Mechanical Properties of Plastic Can Be Greatly Enhanced by Adding a Reinforcing Agent to the Resin. Plastic Resins May Be Reinforced with Cloth, Paper, Glass Fibers, and Other Fibers Such as Graphite, Thus Forming *Advanced Composite Materials*.

- A. Discuss composite molding processes
  - 1. Fiber glassing - alternate layers of glass fibers fabric and resin are coated over a mold or form built in the shape of the finished product. (Examples: spas and boats.)
  - 2. Calendaring or rolling - "plastic is rolled thin to form sheets or film" which is bonded to other materials for protection or other purposes.
  - 3. Plastic materials mixed with paint and sprayed or brushed on products. (Example: polyurethane-based paints.)
  - 4. High-pressure lamination - (Example: plastic laminate bonded over wood base to form a molded top for a kitchen cabinet.) Note: composites differ from reinforced plastics in that the fiber structure is continuous throughout the structure. It is this particular structural design that gives the composite its superior mechanical properties.
- B. Discuss the advantages of composites
  - 1. Excellent strength-to-weight ratio
  - 2. Resistance to corrosion
  - 3. Resistance to impact
  - 4. Ability to be formed into complex shapes
- C. Discuss composite manufacturing methods
  - 1. Pulltrusion - the fiber portion is pulled or drawn through the liquid resin and then through a heated die that forms the desired shape (Example: structural members and tube.)
  - 2. Filament winding - the fiber is wound back and forth on a cylindrical form. After curing, the form is removed leaving the hollow composite product.
  - 3. Laminating - alternate layers of resin containing the structural fiber are rolled or spread over the surface of the mold.

IV. Discuss the Powder Metallurgy Process - Powder Metallurgy, Commonly Known as P/M, Is Essentially the Compression of Finely Divided Metal Powder into a Briquette of the Desired Shape. The Briquette Is Then Heated to Form a Metallurgical Bond Between the Metal Particles. Over Half the P/M Products Are Used in the *Transportation* Industry.

- A. How P/M parts are made. (Basic steps)

1. Compacting (molding) - loose powder (or blend) is placed in a die and pressed into shape (called a green compact). (Usually there is a mixture of different metal powders.) The ejected parts are called "*briquettes.*"
2. *Sintering* - heated in the proper atmosphere to cause the powders to bond together.
3. Secondary operations - sizing, machining, grinding, heat treating, deburring, plating, or impregnating with oil.

B. Producing metal powders. (*Iron* is the most used powder.)

1. Reduction of oxides - iron is heated to mush then crushed.
2. Electrolysis - deposits on a electrical cathode (very pure).
3. Atomization - heated metal is sprayed through a nozzle then ground to the desired fineness.
4. Metal powders range in size from .0001" to .002".

C. Compacting of powders - powders are pressed from both top and bottom in dies that form the powder into the desired shape. Since compaction is from top and bottom, the powders flow in the direction of compaction.

1. Mechanical presses - rapid rate of production (50,000 parts per hr. at about 30 tons of pressure).
2. Hydraulic presses - very high pressure (5,000 tons).

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Name:______________________ Date:______________________

MFG-D6
Evaluate Plastics, Composites and Other Manufacturing Processes
Self-Assessment

Circle the **best** answer which would answer the question:

1. Which of the following is an example of a thermoplastic plastic?
    a. Nylon
    b. Epoxy
    c. Phenolic
    d. Aminos

2. Some plastics are used as adhesives.
    a. True
    b. False

3. "Styrofoam" (trade name) is a common rigid foam made from
    a. Polypropolene
    b. Polystyrene
    c. Polyethylene
    d. Polycarbonate

4. The heaviest plastics are the ___________.
    a. Fluorocarbons
    b. Aminos
    c. Epoxies
    d. Vinyls

5. Most plastics expand or contract with the addition or loss of water.
    a. True
    b. False

6. Which type of plastics are good thermal insulators?
    a. Thermoset plastic
    b. Thermoplastic plastic
    c. PVC
    d. Foamed plastic

7. Which type of plastics are probably more resistant to the effects of acid?
    a. Fluorocarbons
    b. Polyethylenes
    c. Polycarbonates
    d. Phenolics

8. All varieties of plastics are resistant to alkaline solutions.
   a. True
   b. False

9. In this process thermoset plastic is used, the resin is mechanically compacted into a mold shaped to produce the desired end product, and handles and knobs for kitchen utensils can be made.
   a. Injection molding
   b. Compression molding
   c. Rotational molding
   d. Blow molding

10. In this process, molten plastic is forced into a metal die cavity that has been machined to the shape of the desired end product.
   a. Injection molding
   b. Compression molding
   c. Rotational molding
   d. Extrusion

11. Air is used to force a mass of molten plastic against the sides of a mold shaped in the form of the desired end product in this process.
   a. Blow molding
   b. Compression molding
   c. Rotational molding
   d. Extrusion

12. The process (plastic) used to form sheet and film is ________.
   a. Compression molding
   b. Calendaring
   c. Injection molding
   d. Rotational molding

13. Graphite and glass are examples of the fiber materials in composites.
   a. True
   b. False

14. Methods used to manufacture composite materials are pulltrusion, filament winding, and laminating.
   a. True
   b. False

15. The four major methods of shaping metal are machining, hot or cold plastic deformation, casting, and _________.
    a. Fabrication
    b. Assembly
    c. Powder metallurgy
    d. Welding

16. Over one-half of the P/M products manufactured are used in _________.
    a. Transportation
    b. Packaging
    c. Construction
    d. Mining

17. In P/M manufacturing the step requiring heating of the parts;
    a. Compacting
    b. Blending
    c. Sintering
    d. Sizing

18. Parts ejected from a P/M die are called __________.
    a. Castings
    b. Briquettes
    c. Forgings
    d. Compressions

19. Which of the following is *not* a method to produce P/M powders?
    a. Atomization
    b. Flaking
    c. Electrolysis
    d. Reduction of oxide

20. From which type of metal are the largest quantity of powders made?
    a. Iron
    b. Aluminum
    c. Copper
    d. Magnesium

21. Particle size range for metal powders vary from _____ to _____ inches in diameter.
    a. .02"; .0001"
    b. .002"; .0001"
    c. .001"; .0002"
    d. .01"; .002"

22. In the compacting process for P/M, the metal powder flows only in the direction of compaction.
   a. True
   b. False

23. Hydraulic presses have a rate of production that is higher than mechanical presses.
   a. True
   b. False

24. A process in which the pores or voids of a sintered or unsintered compact are filled with a metal or alloy of a lower melting point:
   a. Impregnation
   b. Infiltration
   c. Plating
   d. Dipping

25. In chemical milling the most important application is __________.
   a. Weight reduction
   b. Tapering
   c. Cutting
   d. Etching

26. In the chemical milling process after the metal is cleaned and deoxidized, it is coated with a material that is resistant to chemical action. This coating is called __________.
   a. Resist
   b. Etch-proof
   c. Maskant
   d. Paint

27. The NTM process that is the reverse of electroplating is ______.
   a. Electric discharge machining
   b. Electric beam machining
   c. Electrochemical machining
   d. Laser beam machining

28. The space between the tool and the workpiece in the ________ process is called the machining gap.
   a. Electrochemical machining
   b. Electric discharge machining
   c. Electron beam machining
   d. Ultra sonic machining

29. Electric discharge machining process leaves a better finish overall than the electrochemical machining process.
    a. True
    b. False

30. The electrode (tool) in the EDM process does *not* get arced away.
    a. True
    b. False

31. The length of the spark in the EDM process is called the _____.
    a. Undercut
    b. Gap
    c. Overcut
    d. Arc length

32. A process that uses abrasive materials and an oscillating tool to machine hard, brittle materials that are nonconductors of electricity is called _______.
    a. EBM
    b. USM
    c. EDM
    d. ECM

33. For what process is it necessary to perform operations in a vacuum?
    a. AJM
    b. ECM
    c. EDM
    d. EBM

34. What NTM process involves passing a gas through an electric arc?
    a. Electron beam machining
    b. Laser machining
    c. Plasma arc machining
    d. Abrasive jet machining

MFG-D6

Evaluate Plastics, Composites and Other Manufacturing Processes

Self-Assessment Answer Key

1.	a
2.	a
3.	b
4.	a
5.	b
6.	d
7.	a
8.	b
9.	b
10.	a
11.	a
12.	b
13.	b
14.	a
15.	c
16.	a
17.	c
18.	b
19.	b
20.	a
21.	b
22.	a
23.	b
24.	b
25.	a
26.	c
27.	c
28.	b
29.	b
30.	a
31.	b
32.	b
33.	d
34.	c

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/decimals	B-3 Convert Metric/English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-E1

Subject: **Manufacturing Technology** **Time: 2 Hrs.**

Duty: **Measure/Inspect**
Task: Understand Metrology Terms

Objective(s):

Upon completion of this unit the student will be able to:
a. Discuss the use of metrology in manufacturing;
b. Discuss the Inch system of measurement;
c. Discuss the Metric system of measurement;
d. Discuss semi-precision and precision measurement; and,
e. Discuss the following: precision, reliability, discrimination, and accuracy.

Instructional Materials:

MASTER Handout (MFG-E1-HO)
MASTER Self-Assessment
As many different measurement instruments in both English and metric as is practical

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References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Dimensional Measurement"
NTMA Modules:

MA-I-35	"Fractions"
MA-II-05	"Metric Measurement"

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-B1	"Perform Basic Arithmetic Functions"
MFG-B2	"Convert Fractions/Decimals"
MFG-B3	"Convert Metric/English Measurements"

Introduction:

The world has depended on some form of measurement system since the beginning of civilization. Measurement has progressed through many forms down through the years. Measurement is now referred to as metrology and has, by necessity, become an exact science because of the high degrees of precision required by manufactures and consumers today. Interchangeable manufacture, world trade, and the need for high precision have all contributed to the need for a highly accurate international system of measurement.

Presentation Outline:

- I. Discuss the Use of Metrology in Manufacturing
  - A. Discuss the function and reason for measurements in manufacturing
  - B. Discuss the changes (metrology related) in manufacturing today
    - 1. Interchangeable manufacture
    - 2. World trade
    - 3. High precision
- II. Discuss the Inch System of Measurement
  - A. Discuss fractional (scale) dimensions for linear measurement
  - B. Discuss decimal dimensions for linear measurement
  - C. Convert fractional to decimal
    - 1. Review mathematical conversion method
    - 2. Fractional/decimal conversion charts
  - D. Practice and demonstration of skills listed above
- III. Discuss the Metric System of Measurement
  - A. Discuss the units of measure commonly used in the metric system
  - B. Convert inch to metric
    - 1. Review mathematical method (1 inch = 25.4 mm)
    - 2. Conversion charts
  - C. Practice and demonstration of skills listed above
- IV. Discuss Semi-Precision and Precision Measurement
  - A. Discuss the difference between semi-precision and precision measurement
    - 1. Semi-precision measurements are 1/64" (.5mm) or greater
    - 2. Precision measurements are less than 1/64" (.5mm)
  - B. Discuss the five categories of precision measurement
    - 1. Outside measurement
    - 2. Inside measurement
    - 3. Depth measurement
    - 4. Thread measurement
    - 5. Height measurement
- V. Discuss the Following Measurement Terms: Accuracy, Precision, Reliability, and Discrimination

A. *Accuracy* - whether or not something is made according to standard. (The standard for manufacturing is the blueprint.)
B. *Precision* - the degree of exactness required for an application or design requirement
C. *Reliability* - the ability to consistently obtain the desired result
D. *Discrimination* - the degree that a measuring instrument divides its basic unit of length

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Practical Application:

Students will understand the differences in metric and English measurements, will recognize different measuring tools, and will understand the principles of precision measurement.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-E2) dealing with the selection of the correct measuring tool based on tool characteristics and measurement requirements.

MFG-E1-HO
Understand Metrology Terms
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Discuss the use of metrology in manufacturing;
- b. Discuss the Inch system of measurement;
- c. Discuss the Metric system of measurement;
- d. Discuss semi-precision and precision measurement; and,
- e. Discuss the following: precision, reliability, discrimination, and accuracy.

Module Outline:

- I. Discuss the Use of Metrology in Manufacturing
  - A. Discuss the function and reason for measurements in manufacturing
  - B. Discuss the changes (metrology related) in manufacturing today
    - 1. Interchangeable manufacture
    - 2. World trade
    - 3. High precision
- II. Discuss the Inch System of Measurement
  - A. Discuss fractional (scale) dimensions for linear measurement
  - B. Discuss decimal dimensions for linear measurement
  - C. Convert fractional to decimal
    - 1. Review mathematical conversion method
    - 2. Fractional/decimal conversion charts
  - D. Practice and demonstration of skills listed above
- III. Discuss the Metric System of Measurement
  - A. Discuss the units of measure commonly used in the metric system
  - B. Convert inch to metric
    - 1. Review mathematical method (1 inch = 25.4 mm)
    - 2. Conversion charts
  - C. Practice and demonstration of skills listed above
- IV. Discuss Semi-Precision and Precision Measurement
  - A. Discuss the difference between semi-precision and precision measurement
    - 1. Semi-precision measurements are 1/64" (.5mm) or greater
    - 2. Precision measurements are less than 1/64" (.5mm)
  - B. Discuss the five categories of precision measurement
    - 1. Outside measurement
    - 2. Inside measurement
    - 3. Depth measurement

    4. **Thread measurement**
    5. **Height measurement**

V. **Discuss the Following Measurement Terms:** Accuracy, Precision, Reliability, **and Discrimination**

  A. ***Accuracy*** **- whether or not something is made according to standard. (The standard for manufacturing is the blueprint.)**
  B. ***Precision*** **- the degree of exactness required for an application or design requirement**
  C. ***Reliability*** **- the ability to consistently obtain the desired result**
  D. ***Discrimination*** **- the degree that a measuring instrument divides its basic unit of length**

Name____________________________ Date_______________

MFG-E1
Understand Metrology Terms
Self-Assessment

Circle the letter preceding the correct answer.

1. Which of the following is **not** a term for the science of measuring?
    A. Calibration
    B. Comparison
    C. Measurology
    D. Metrology

2. Name two systems of measurement presently used in the United States.
    A. Fractions and decimals
    B. Metric and inch
    C. Precision and non-precision
    D. Inside and outside

3. What is the most common inch to metric conversion factor in use today?
    A. 1" = 25.4mm
    B. 1mm = .25.4"
    C. 1' = 12mm
    D. 1/16" = 64mm

4. Precision measurement can be defined as any measurement made to a degree finer than:
    A. 1/8".
    B. 1/16".
    C. 1/32".
    D. 1/64".

5. Precision measurement can also be defined as any measurement made to a degree finer than:
    A. .25mm.
    B. .5mm.
    C. .10mm.
    D. 3.24mm.

6. _______________ in metrology refers to whether or not a specific measurement is actually within its stated size.
   A. Precision
   B. Reliability
   C. Discrimination
   D. Accuracy

7. _______________ in metrology is relative to the specific measurement being made, with regard to the degree of exactness required.
   A. Precision
   B. Reliability
   C. Discrimination
   D. Accuracy

8. _______________ in metrology refers to the degree to which a measuring instrument divides the basic unit of length it is using for measurement.
   A. Precision
   B. Reliability
   C. Discrimination
   D. Accuracy

9. _______________ in metrology refers to the ability to obtain the desired result to the degree of precision required.
   A. Precision
   B. Reliability
   C. Discrimination
   D. Accuracy

10. The five categories of precision measurement are outside, inside, length, depth, and:
   A. Taper
   B. Rpm
   C. Thread
   D. Rms

MFG-E1
Understand Metrology Terms
Self-Assessment Answer Key

1. B
2. B
3. A
4. D
5. B
6. D
7. A
8. C
9. B
10. C

MFG-E2

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-E2

Subject: **Manufacturing Technology** **Time: 4 Hrs.**

Duty: **Measure/Inspect**
Task: Select Measurement Tools

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify basic semi-precision measuring tools;
b. Identify precision measuring tools;
c. Justify use of particular measurement tools based on tool characteristics;
d. Identify error possibilities in measurement tool selection; and,
e. Demonstrate proper care of precision measuring tools.

Instructional Materials:

MASTER Handout (MFG-E2-HO)
MASTER Laboratory Aid (MFG-E2-LA)
MASTER Self-Assessment
Steel Rules (metric and fractional)
0-1" micrometer
Assortment of outside (larger than 1") micrometers
1 set inside micrometers
1 depth micrometer set
1 ea. - outside spring caliper and inside spring caliper
6" dial calipers
1 ea. - Digital micrometer and digital vernier caliper
1 ea. - Set of telescoping gages and set of small hole gages
Examples of "go/no-go" gages

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Dimensional Measurement"

NTMA Modules:

MA-I-05	"Steel Rules"
MA-I-09	"Steel Rules and Transfer Tools"
MA-I-13	"Micrometers"
MA-I-17	"Vernier Instruments

Student Preparation:

Students should have previously completed the following MASTER Technical Modules:

MFG-E1 "Understand Metrology Terms"

Introduction:

A person choosing to enter the machinist trade is often surprised at the number of measuring tools available to such workers. With hundreds of these tools to choose from, the machinist has a tool to cover almost any conceivable measuring situation. Often these tools are used alone or in combination with other measuring tools. As you begin your machinist career, it is important that you learn to properly identify, use and care for these precision instruments.

Presentation Outline:

- I. Describe and Discuss the Following Semi-Precision Measuring Tools
  - A. Steel rules
  - B. Calipers
  - C. Squares
- II. Describe and Discuss the Following Precision Measuring Tools
  - A. Micrometers (outside, inside and depth)
  - B. Verniers (calipers and height gage)
  - C. Gages (small hole, telescope, fixed, and dial bore)
- III. Justify Use of Particular Measurement Tools Based on Tool Characteristics
  - A. What tolerance is required by the print?
  - B. What physical characteristics of the part influence tool selection?
  - C. What is the discrimination of the tool?
  - D. How much time is available for part measurement/inspection?
  - E. Will the tool be used by itself or in conjunction with some other tool?
  - F. What is the most reliable tool for this application?
- IV. Identify Error Possibilities in Measurement Tool Selection
  - A. Part not being produced to specifications
  - B. Too much time spent trying to measure correctly by not having the right tool
- V. Demonstrate Proper Care of Precision Measuring Tools
  - A. Storage
  - B. Handling
  - C. Cleaning

Practical Application:

Complete the Self-Assessment at the end of the chapters in the text.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-E3) dealing with measuring with hand held machinist measuring instruments.

MFG-E2-HO
Select Measurement Tools
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify basic semi-precision measuring tools;
b. Identify precision measuring tools;
c. Justify use of particular measurement tools based on tool characteristics;
d. Identify error possibilities in measurement tool selection; and,
e. Demonstrate proper care of precision measuring tools.

Module Outline:

I. Describe and Discuss the Following Semi-Precision Measuring Tools
  A. Steel rules
  B. Calipers
  C. Squares
II. Describe and Discuss the Following Precision Measuring Tools
  A. Micrometers (outside, inside and depth)
  B. Verniers (calipers and height gage)
  C. Gages (small hole, telescope, fixed, and dial bore)
III. Justify Use of Particular Measurement Tools Based on Tool Characteristics
  A. What tolerance is required by the print?
  B. What physical characteristics of the part influence tool selection?
  C. What is the discrimination of the tool?
  D. How much time is available for part measurement/inspection?
  E. Will the tool be used by itself or in conjunction with some other tool?
  F. What is the most reliable tool for this application?
IV. Identify Error Possibilities in Measurement Tool Selection
  A. Part not being produced to specifications
  B. Too much time spent trying to measure correctly by not having the right tool
V. Demonstrate Proper Care of Precision Measuring Tools
  A. Storage
  B. Handling
  C. Cleaning

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name______________________________ Date________________

MFG-E2
Select Measurement Tools
Self-Assessment

Circle the letter preceding the best answer.

1. A ______________ is a linear measuring instrument whose graduations represent real units of length .
   A. Steel tape
   B. Scale
   C. Rule
   D. Yardstick

2. A vernier caliper has two scales: the vernier scale and the________________.
   A. Top scale
   B. Main scale
   C. Principle scale
   D. Inside scale

3. What is the discrimination for vernier instruments used for linear measurement?
   A. .001"
   B. .02mm
   C. 1/64"
   D. A and B above

4. How are metric scales usually graduated?
   A. Meters
   B. Feet and inches
   C. Milliliters
   D. MM and .5mm

5. The machinist combination set incudes 4 components: the steel rule, the protractor head, the square head, and ______________ .
   A. Magnetic base
   B. Protective cover
   C. Center head
   D. Adjustable depth gage

6. The vernier caliper may be used for inside measurement, outside measurement and ________________ .
   - A. Diameter measurement
   - B. Length measurement
   - C. Depth measurement
   - D. All of the above

7. Which of the following is not a valid type of micrometer?
   - A. Outside micrometer
   - B. Universal micrometer
   - C. Thread micrometer
   - D. Digital micrometer

8. Which of the following does the most harm to precision measuring tools?
   - A. Heat
   - B. Dirt
   - C. Moisture
   - D. Oil

9. A standard micrometer has a discrimination of what part of an inch?
   - A. .0001"
   - B. .001"
   - C. .010"
   - D. .100"

10. In order to be certain of the dimension when measuring with a micrometer: ________________ .
    - A. Take at least one reading
    - B. Take at least two readings
    - C. Take at least three readings
    - D. Take at least four readings

MFG-E2
Select Measurement Tools
Self-Assessment Answer Key

1. C

2. B

3. D

4. D

5. C

6. D

7. B

8. C

9. B

10. B

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-E3

Subject: **Manufacturing Technology** **Time: 4 Hrs.**

Duty: **Measure/Inspect**
Task: Measure with Hand Held Instruments

Objective(s):

Upon completion of this unit the student will be able to:

a. Measure with steel rules (metric and inch);
b. Measure with micrometers;
c. Measure with comparison measuring instruments (e.g., calipers, telescope gages);
d. Measure with direct measuring instruments (e.g., vernier, dial and digital instruments); and,
e. Measure with fixed gages (go and no-go gages).

Instructional Materials:

MASTER Handout (MFG-E3-HO)
MASTER Laboratory Exercise (MFG-E3-LE1)
MASTER Laboratory Exercise (MFG-E3-LE2)
MASTER Laboratory Aid (MFG-E3-LA)
Steel Rules (metric and fractional) for each student or group of students
0-1" micrometers for each student or group of students
Assortment of outside (larger than 1") micrometers
1 set inside micrometers
1 depth micrometer set
1 ea. - outside spring caliper and inside spring caliper
6" dial calipers for each student or group of students
Random collection of objects for student practice
1 ea. - Digital micrometer and digital vernier caliper
1 ea. - Set of telescoping gages and set of small hole gages
Examples of "go/no-go" gages

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Dimensional Measurement"
NTMA Modules:
MA-I-05 "Steel Rules"

MA-I-09 “Steel Rules and Transfer Tools”
MA-I-13 “Micrometers”
MA-I-17 “Vernier Instruments”

Student Preparation:

Students should have previously completed the following MASTER Technical Modules:

MFG-E1 “Understand Metrology Terms”
MFG-E2 “Select Measurement Tools”

Introduction:

Every aspect of our lives, from the clothes we wear to the cars we drive, is greatly influenced by measurement. For the machinist, measurement is especially important since it is the machinist who is responsible for crafting the tools, fixtures, and components which make up or support virtually every part of our lives. Therefore, it is essential for the machinist to be a master in the use of not only the machine tools, but also the instruments which are used to measure the precision components demanded by consumers today. One of the most valuable assets you can possess is the expert use of the machinist measuring tools and a desire to practice quality consciousness in every aspect of your job performance.

Presentation Outline:

I. Discuss the Importance of Learning and Practicing Proper Measurement Techniques
    A. Show the video “Measuring Tools”
    B. Give each student a copy of the handout “Proper Measuring Techniques”
II. Discuss and Demonstrate Proper Measurement Techniques Using the Steel Rule
III. Discuss and Demonstrate the Use of Micrometer Type Measuring Instruments
    A. Outside micrometers
    B. Inside micrometers
    C. Depth micrometers
    D. Practice and demonstration of skills listed above
IV. Discuss and Demonstrate the Use of Transfer Type Measuring Instruments
    A. Spring calipers (inside and outside)
    B. Telescope gages
    C. Small hole gages
    D. Practice and demonstration of skills listed above
V. Discuss and Demonstrate the Use of Direct Measuring Instruments

A. Vernier calipers
B. Dial calipers
C. Digital calipers
D. Practice and demonstration of skills listed above

VI. Discuss the Purpose of Fixed Gages and Demonstrate Their Use
A. Cylindrical plug and ring gages
B. Taper plug and ring gages
C. Snap gages
D. Thread plug gages
E. Practice and demonstration of skills listed above

VII. Complete Practical Exercises (MFG-E3-LE1) and (MFG-E3-LE2) On All the Above Material

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Practical Application:

Students will practice in the lab with each measuring instrument and complete the Laboratory Worksheet (MFG-E3-LW) and turn it in to the instructor for evaluation.

Evaluation and/or Verification:

Given: All the measuring instruments listed in the "Instructional Materials" and appropriate sample workpieces to measure;

The student will: Study the material as presented by the instructor, evaluate his/her skills through the Self-Assessment, and demonstrate those skills through the Laboratory Worksheet.

The standards of skill performance are that the student will:

1. Score 90% on the Self-Assessment;
2. Measure with the steel rule to an accuracy of ±1/64 inch;
3. Measure with the micrometer to an accuracy of ±0.001 inch;
4. Measure with the dial and digital caliper to an accuracy of ±0.001 inch; and,
5. Determine whether the holes, tapers, and threads are within acceptable limits by use of the appropriate go/no-go gages.

Summary:

Review the main lesson points. Hold class discussion and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-E4) dealing with eliminating variables which affect accurate measurement.

MFG-E3-HO
Measure With Hand Held Instruments
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Measure with steel rules (metric and inch);
- b. Measure with micrometers;
- c. Measure with comparison measuring instruments (e.g., calipers, telescope gages);
- d. Measure with direct measuring instruments (e.g., vernier, dial and digital instruments); and,
- e. Measure with fixed gages (go and no-go gages).

Module Outline:

- I. Discuss the Importance of Learning and Practicing Proper Measurement Techniques
  - A. Show the video "Measuring Tools"
  - B. Give each student a copy of the handout "Proper Measuring Techniques"
- II. Discuss and Demonstrate Proper Measurement Techniques Using the Steel Rule
- III. Discuss and Demonstrate the Use of Micrometer Type Measuring Instruments
  - A. Outside micrometers
  - B. Inside micrometers
  - C. Depth micrometers
  - D. Practice and demonstration of skills listed above
- IV. Discuss and Demonstrate the Use of Transfer Type Measuring Instruments
  - A. Spring calipers (inside and outside)
  - B. Telescope gages
  - C. Small hole gages
  - D. Practice and demonstration of skills listed above
- V. Discuss and Demonstrate the Use of Direct Measuring Instruments
  - A. Vernier calipers
  - B. Dial calipers
  - C. Digital calipers
  - D. Practice and demonstration of skills listed above
- VI. Discuss the Purpose of Fixed Gages and Demonstrate Their Use
  - A. Cylindrical plug and ring gages
  - B. Taper plug and ring gages
  - C. Snap gages
  - D. Thread plug gages
  - E. Practice and demonstration of skills listed above

VII. Complete Practical Exercise (MFG-E3-LE1) and (MFG-E3-LE2) On All the Above Material

Name:__________________ Date:________________________

MFG-E3-LE1
Measure With Hand Held Instruments
Attachment 2: MASTER Laboratory Exercise No. 1

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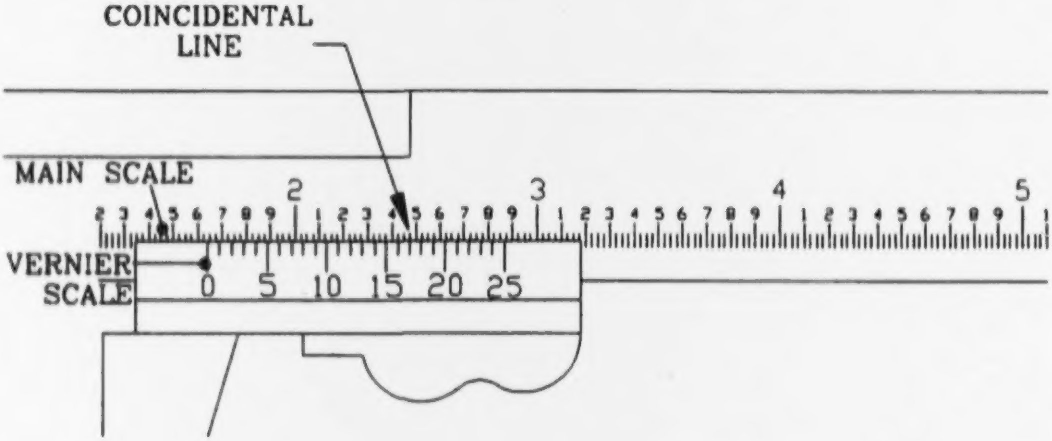
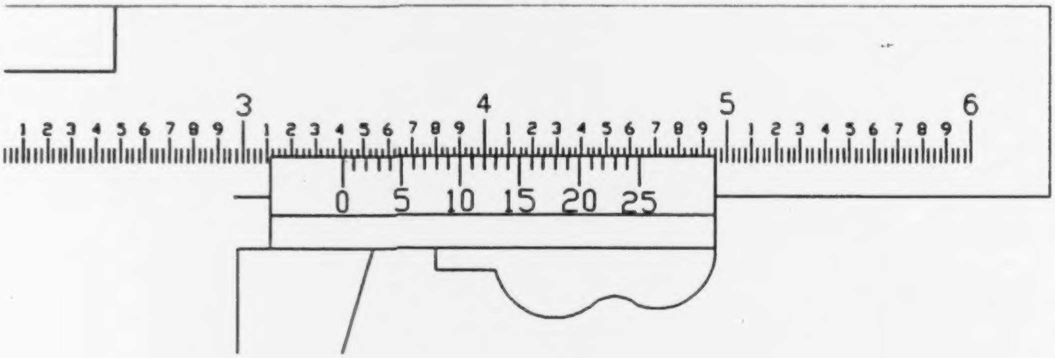
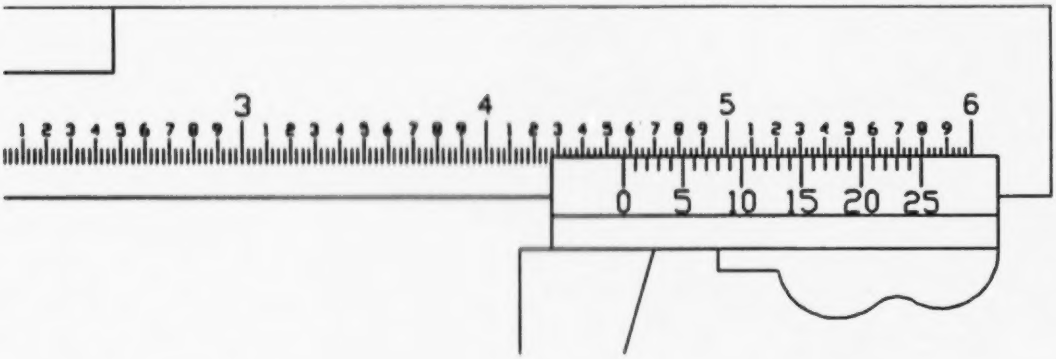
1. What is the reading on the vernier caliper below?
   - a. .642
   - b. 1.642
   - c. 1.645
   - d. 1.64


COINCIDENTAL LINE
MAIN SCALE
VERNIER SCALE
2
3
4
5
0 5 10 15 20 25

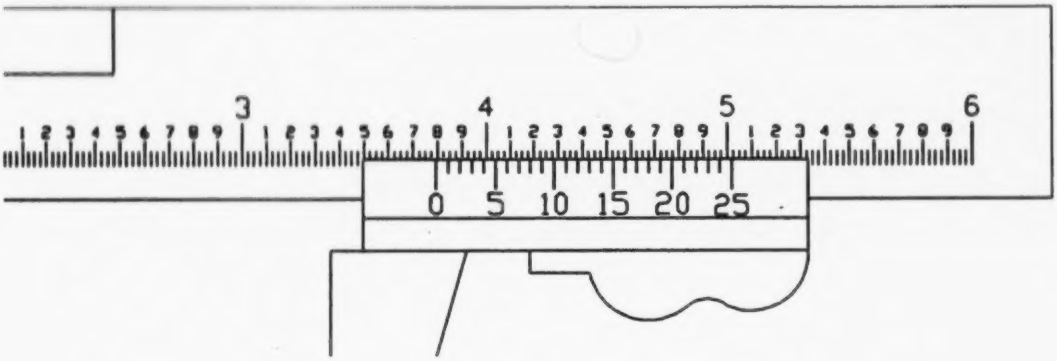
2. What is the reading on the vernier caliper below?
   - a. .415
   - b. 3.125
   - c. 3.405
   - d. 3.412


3
4
5
6
0 5 10 15 20 25

3. **What is the reading on the vernier caliper below?**
   a. 4.575
   b. 4.250
   c. 4.570
   d. 4.275


3
4
5
6
1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9
0 5 10 15 20 25

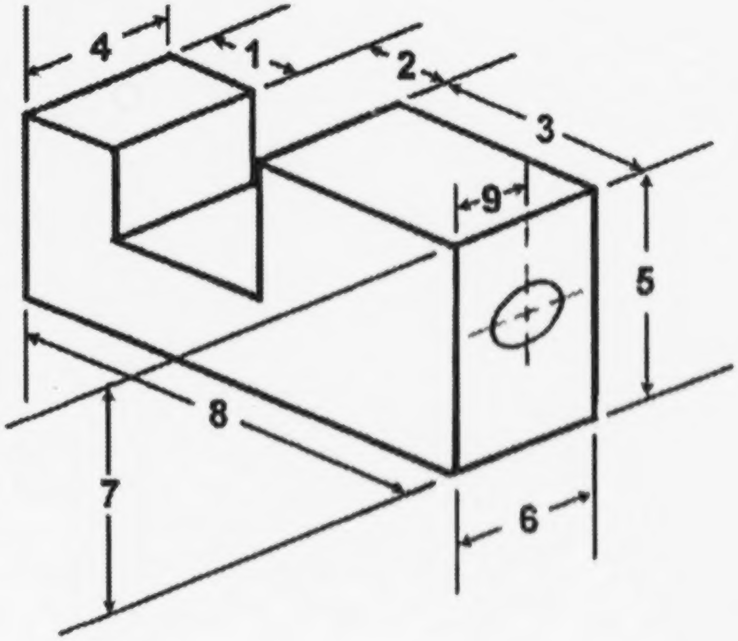
4. **What is the reading on this vernier caliper?**
   a. 3.785
   b. 3.800
   c. 3.473
   d. 3.793


3
4
5
6
1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9
0 5 10 15 20 25

Name______________________________ Date________________

MFG-E3-LE2
Measure With Hand Held Instruments
Attachment 3: MASTER Laboratory Exercise No. 2

Using the measuring instruments provided for you and the measuring specimens, measure for the following dimensions and record your answers in the space provided. Be sure to provide metric and inch answers for each dimension. Turn this sheet in to your instructor for evaluation.



Specimen Number _______

Dimension	metric	inch	Dimension	metric	inch
1.	_____	_____	7.	_____	_____
2.	_____	_____	8.	_____	_____
3.	_____	_____	9.	_____	_____
4.	_____	_____	10.	_____	_____
5.	_____	_____	11.	_____	_____
6.	_____	_____			

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-E4

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-E4

Subject: **Manufacturing Technology** **Time: 4 Hrs.**

Duty: **Measure/Inspect**
Task: Eliminate Measurement Variables

Objective(s):

Upon completion of this unit the student will be able to:

a. Discuss factors affecting accurate measurement (dirt, temperature, improper measuring tool calibration);
b. Explain calibration requirements of various precision instruments;
c. Illustrate measurement differences when taken with calibrated and non-calibrated instruments; and,
d. Calibrate a micrometer type measuring tool.

Instructional Materials:

MASTER Handout (MFG-E4-HO)
MASTER Laboratory Exercise (MFG-E4-LE)
MASTER Laboratory Aid (MFG-E4-LA)
MASTER Self-Assessment
Assortment of outside micrometers with standards and adjusting wrench
Dial calipers with adjustment tool
Set of gage blocks

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Dimensional Measurement"

Student Preparation:

Students should have previously completed the following MASTER Technical Modules:

MFG-E1	"Understand Metrology Terms"
MFG-E2	"Select Measurement Tools"
MFG-E3	"Measure With Hand Held Instruments"

Introduction:

Simply possessing the finest measuring tools that money can buy does not insure precision measurement. Many other factors affect accurate measurement. The machinist must learn how to prepare the surface for measurement, how to manipulate the measuring tools correctly, and how to check the calibration of those measuring tools. All of these things are important if the machinist is to consistently make accurate measurements.

Presentation Outline:

I. Discuss Factors Affecting Accurate Measurement
    A. Tool selection
    B. Cleanliness
    C. Temperature
    D. Calibration
    E. "Feel"
II. Explain Calibration Requirements of Various Precision Instruments
    A. Individual responsibility vs. company responsibility
    B. Calibration standards
III. Illustrate Measurement Differences When Taken With Calibrated and Non-Calibrated Instruments
IV. Calibrate a Micrometer Type Measuring Tool
    A. 5 steps adjusting an outside micrometer which needs adjustment
        1. Clean the measuring faces of the micrometer
        2. Close the measuring faces carefully against the standard by turning the ratchet stop or friction thimble
        3. Insert the C-spanner into the hole or slot provided in the sleeve
        4. Carefully turn the sleeve until the index line on the sleeve coincides with the zero line on the thimble
        5. Recheck the accuracy of the micrometer by opening and then closing the micrometer faces by turning the ratchet stop or friction thimble
    B. Student practice of the above procedure

Practical Application:

Students will clean, check and calibrate an outside micrometer.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-E5) on the subject of performing measurements and inspections using a surface plate and accessories

MFG-E4-HO
Eliminate Measurement Variables
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Discuss factors affecting accurate measurement (dirt, temperature, improper measuring tool calibration);
b. Explain calibration requirements of various precision instruments;
c. Illustrate measurement differences when taken with calibrated and non-calibrated instruments; and,
d. Calibrate a micrometer type measuring tool.

Module Outline:

I. Discuss Factors Affecting Accurate Measurement
    A. Tool selection
    B. Cleanliness
    C. Temperature
    D. Calibration
    E. "Feel"
II. Explain Calibration Requirements of Various Precision Instruments
    A. Individual responsibility vs. company responsibility
    B. Calibration standards
III. Illustrate Measurement Differences When Taken With Calibrated and Non-Calibrated Instruments
IV. Calibrate a Micrometer Type Measuring Tool
    A. 5 steps adjusting an outside micrometer which needs adjustment
        1. Clean the measuring faces of the micrometer
        2. Close the measuring faces carefully against the standard by turning the ratchet stop or friction thimble
        3. Insert the C-spanner into the hole or slot provided in the sleeve
        4. Carefully turn the sleeve until the index line on the sleeve coincides with the zero line on the thimble
        5. Recheck the accuracy of the micrometer by opening and then closing the micrometer faces by turning the ratchet stop or friction thimble
    B. Student practice of the above procedure

MFG-E4-LE
Eliminate Measurement Variables
Attachment 2: MASTER Laboratory Exercise

The student will perform the following:

1. Calibrate a micrometer by:
   a. Adjusting micrometer;
   b. Cleaning the measuring faces of the micrometer;
   c. Closing the measuring faces carefully against the standard by turning the ratchet stop or friction thimble;
   d. Inserting the C-spanner into the hole or slot provided in the sleeve;
   e. Carefully turning the sleeve until the index line on the sleeve coincides with the zero line on the thimble; and,
   f. Rechecking the accuracy of the micrometer by opening and then closing the micrometer faces by turning the ratchet stop or friction thimble.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name______________________________ Date_________________

MFG-E4
Eliminate Measurement Variables
Self-Assessment

Write the answers to the following questions in the space provided.

1. List 5 factors which may affect accurate measurement.

____

____

____

____

____

2. Briefly explain why some companies place the burden of calibration on the machinist while other companies employ persons to calibrate the tools and instruments of the machinist.

____

____

____

____

3. Even though standards are furnished with many outside micrometers, what is generally considered to the best standard to use for calibration of machinist measuring instruments?

____

____

4. **Why are many inspection/quality control stations located in climate controlled areas?**

____

____

____

5. **List the steps (in order) to follow should the accuracy of a micrometer require adjustment.**

    1. ____

       ____

    2. ____

       ____

    3. ____

       ____

    4. ____

       ____

    5. ____

       ____

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-E5

Subject: **Manufacturing Technology** **Time: 8 Hrs.**

Duty: **Measure/Inspect**
Task: Measure/Inspect Using Surface Plate and Accessories

Objective(s):

Upon completion of this unit the student will be able to:

a. Describe care of surface plate;
b. Use surface plate accessories correctly (sine bar, gage blocks, etc.);
c. Check for part squareness;
d. Check part dimensions for accuracy; and,
e. Align workpieces using height gage and dial indicators.

Instructional Materials:

MASTER Handout (MFG-E5-HO)
MASTER Laboratory Exercise (MFG-E5-LE)
MASTER Laboratory Aid (MFG-E5-LA)
MASTER Self-Assessment
Surface plate and accessories
Parts to check

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Layout"

Student Preparation:

Students should have previously completed the following MASTER Technical Modules:

MFG-E1 "Understand Metrology Terms"
MFG-E2 "Select Measurement Tools"
MFG-E3 "Measure With Hand Held Instruments"
MFG-E4 "Eliminate Measurement Variables"

Introduction:

Much of the measuring that a machinist performs is done at various points during the processing of the workpiece. Whenever a higher degree of precision is required or whenever the work has been removed from the machine, the work is often subjected to inspection. This inspection process is frequently accomplished on a surface plate using a set of accessories which are specifically for use with the surface plate. This lesson will cover the use of the surface plate and the accessories which are used for layout and inspection purposes.

Presentation Outline:

I. Describe Types of Surface Plate and Surface Tables
  A. Cast iron and semi-steel surface plates
  B. Granite surface plate
II. Discuss the Different Surface Plate Accessories and Their Use
  A. Sine bar
  B. Gage blocks
  C. Vernier height gage
  D. Precision height gage
  E. Dial test indicator
  F. Squares
  G. Angle plate and clamps
  H. 1,2,3 blocks
III. Demonstrate Checking For Part Squareness
IV. Demonstrate Checking Part Dimensions For Accuracy
V. Demonstrate Aligning Workpieces Using Height Gage and Dial Indicators

Practical Application:

Students will complete assignments using a surface plate, gage blocks, sine bar, and other accessories normally used in conjunction with the surface plate.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-E6) dealing with the use of stationary equipment for inspection purposes.

MFG-E5-HO
Measure/Inspect Using Surface Plate and Accessories
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Describe care of surface plate;
- b. Use surface plate accessories correctly (sine bar, gage blocks, etc.);
- c. Check for part squareness;
- d. Check part dimensions for accuracy; and,
- e. Align workpieces using height gage and dial indicators.

Module Outline:

- I. Describe Types of Surface Plate and Surface Tables
  - A. Cast iron and semi-steel surface plates
  - B. Granite surface plate
- II. Discuss the Different Surface Plate Accessories and Their Use
  - A. Sine bar
  - B. Gage blocks
  - C. Vernier height gage
  - D. Precision height gage
  - E. Dial test indicator
  - F. Squares
  - G. Angle plate and clamps
  - H. 1,2,3 blocks
- III. Demonstrate Checking For Part Squareness
- IV. Demonstrate Checking Part Dimensions For Accuracy
- V. Demonstrate Aligning Workpieces Using Height Gage and Dial Indicators

MFG-E5-LE
Measure/Inspect Using Surface Plate and Accessories
Attachment 2: MASTER Laboratory Exercise

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1. Instructor will provide sample mechanical parts for students to:
   a. Demonstrate checking for part squareness;
   b. Demonstrate checking part dimensions for accuracy; and,
   c. Demonstrate aligning workpieces using height gage and dial indicators.

2. Students will practice:
   a. Checking for part squareness;
   b. Checking part dimensions for accuracy; and,
   c. Aligning workpieces using height gage and dial indicators.

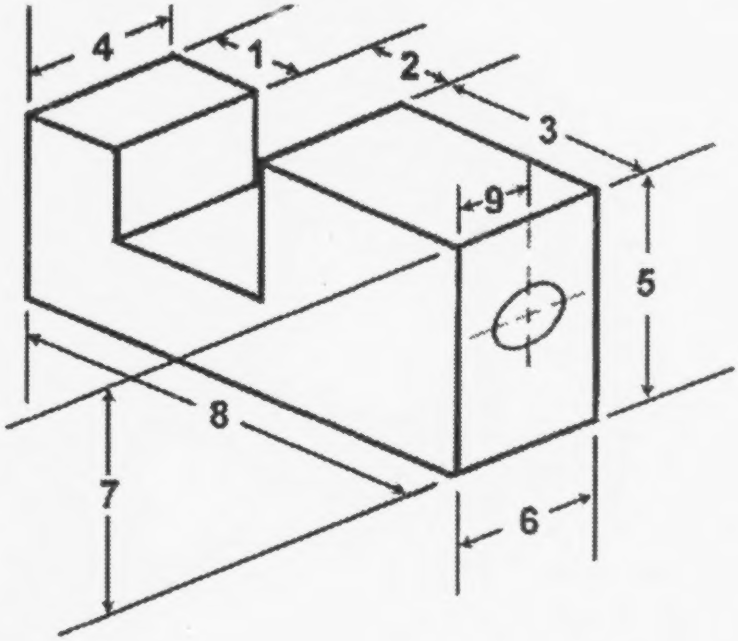
Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name______________________________ Date_________________

MFG-E5
Measure/Inspect Using Surface Plate and Accessories
Self-Assessment

Using the measuring instruments provided for you and the measuring specimens, measure for the following dimensions and record your answers in the space provided. Be sure to provide metric and inch answers for each dimension. Turn this sheet in to your instructor for evaluation.



Dimension	metric	inch	Dimension	metric	inch
1.	_____	_____	11.	_____	_____
2.	_____	_____	12.	_____	_____
3.	_____	_____	13.	_____	_____
4.	_____	_____	14.	_____	_____
5.	_____	_____	15.	_____	_____

6. ____ ____

7. ____ ____

8. ____ ____

9. ____ ____

10. ____ ____

16. ____ ____

17. ____ ____

18. ____ ____

19. ____ ____

20. ____ ____

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-E6

Subject: **Manufacturing Technology** **Time: 12 Hrs.**

Duty: **Measure/Inspect**
Task: Inspect Using Stationary Equipment

Objective(s):

Upon completion of this unit the student will be able to:
a. Set up and use an Optical Comparator; and,
b. Set up and use a Coordinate Measuring Machine (CMM).

Instructional Materials:

MASTER Handout (MFG-E6-HO)
MASTER Laboratory Exercise (MFG-E6-LE)
MASTER Laboratory Aid (MFG-E6-LA)
MASTER Self-Assessment
Optical Comparator
Coordinate Measuring Machine
Samples for Measurement

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition
Instructor's Manual, Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition
Workbook for Machining Fundamentals, John R. Walker, The Goodheart-Willcox Company, Inc. Publishing, Latest Edition

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-E1	"Understand Metrology Terms"
MFG-E2	"Select Measurement Tools"
MFG-E3	"Measure With Hand Held Instruments"
MFG-E4	"Eliminate Measurement Variables"
MFG-E5	"Measure/Inspect Using Surface Plate and Accessories"

Introduction:

Today's manufacturing processes require much higher degrees of precision. Many components are also manufactured at one location then shipped to another for assembly. These factors have caused the machinist to rely more and more on measuring and inspecting instruments with higher degrees of precision. Free standing inspection devices such as the optical comparator and the coordinate measuring machine (CMM) are being used to help the machinist maintain the high levels of precision required by manufacturers and consumers alike.

Presentation Outline:

I. Define the Term "Comparison Measurement"
  A. Describe the following comparison instruments:
    1. Dial indicator
    2. Mechanical comparator
    3. Optical comparator
    4. Mechanical-optical comparator
    5. Air gages
    6. Electronic comparator
  B. Demonstrate the setup and operation of the optical comparator
  C. Allow students to practice setup and operation of the optical comparator
II. Discuss the Advantages of Measuring with the Coordinate Measuring Machine (CMM)
  A. Demonstrate the setup and operation of the CMM
  B. Allow students to practice setup and operation of the CMM

Practical Application:

Students will complete assignments using the optical comparator and the coordinate measuring machine.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-F1) dealing with preparing and planning for conventional machining operations.

MFG-E6-HO
Inspect Using Stationary Equipment
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Set up and use an Optical Comparator; and,

b. Set up and use a Coordinate Measuring Machine (CMM).

Module Outline:

I. Define the Term "Comparison Measurement"
  A. Describe the following comparison instruments:
    1. Dial indicator
    2. Mechanical comparator
    3. Optical comparator
    4. Mechanical-optical comparator
    5. Air gages
    6. Electronic comparator
  B. Demonstrate the setup and operation of the optical comparator
  C. Allow students to practice setup and operation of the optical comparator

II. Discuss the Advantages of Measuring with the Coordinate Measuring Machine (CMM)
  A. Demonstrate the setup and operation of the CMM
  B. Allow students to practice setup and operation of the CMM

MFG-E6-LE
Inspect Using Stationary Equipment
Attachment 2: MASTER Laboratory Exercise

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1. The instructor will:
   a. Demonstrate the setup and operation of the optical comparator; and,
   b. Demonstrate the setup and operation of the Coordinate Measuring Machine (CMM).

2. The students will:
   a. Practice the setup and operation of the optical comparator; and,
   b. Practice the setup and operation of the Coordinate Measuring Machine (CMM).

MFG-E6-LA
Inspect Using Stationary Equipment
Attachment 3: MASTER Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
   a. No loose clothing, including ties;
   b. Long hair properly stowed;
   c. No jewelry;
   d. Hard, closed-toe shoes;
   e. Eye protection (safety glasses); and,
   f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name____________________________ Date________________

MFG-E6
Inspect Using Stationary Equipment
Self-Assessment

Circle the letter preceding the best answer.

1. The CMM measures workpieces in ___ dimensions.
   A. One
   B. Two
   C. Three
   D. Four
   E. None of the above answers is correct.

2. Optical comparators project a ___ shadow of the object.
   A. Magnified
   B. True size
   C. Miniaturized
   D. Any of the above answers could be correct, depending on how the machinist sets up the comparator.
   E. None of the above answers is correct.

3. Which of the following *cannot* be checked using the optical comparator?
   A. Screw threads
   B. Gears
   C. Cutting tools
   D. All of the above are normally checked with optical comparators.
   E. None of the above answers is correct.

4. The optical comparator often uses ___ to check the workpiece.
   A. Ideal models
   B. Templates
   C. Photographs
   D. All of the above are used with the comparator.
   E. None of the above answers is correct.

5. The CMM is useful for checking ___ among parts.
   A. Relative locations
   B. Relative sizes
   C. Relative weights
   D. All of the above answers are correct.
   E. None of the above answers is correct.

MFG-E6
Inspect Using Stationary Equipment
Self-Assessment Answer Key

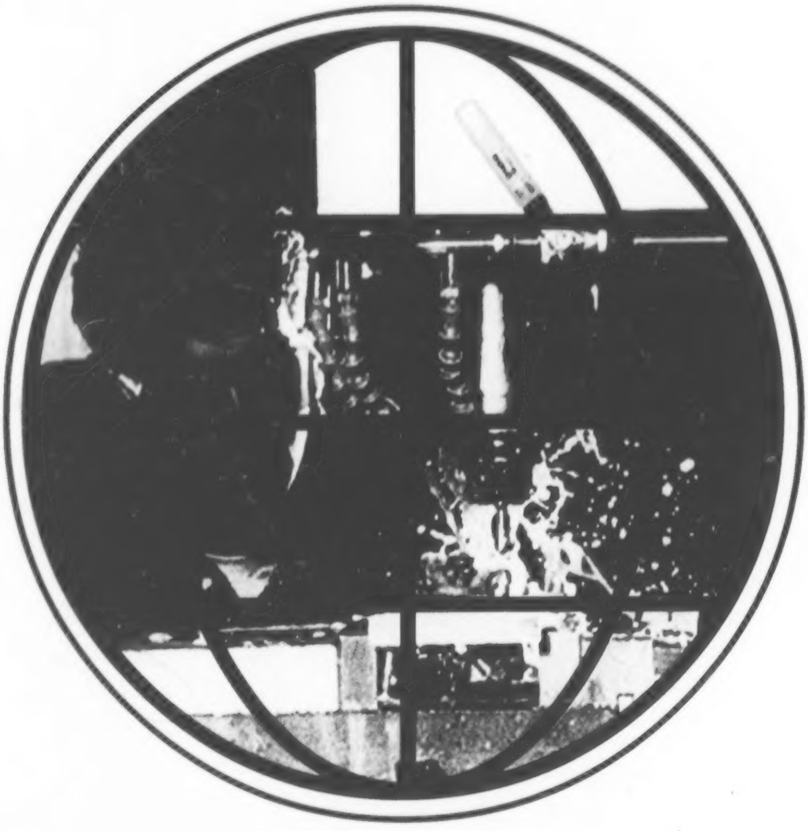
1. C
2. A
3. D
4. B
5. A

MASTER

MACHINE TOOL ADVANCED SKILLS TECHNOLOGY EDUCATIONAL RESOURCES

a consortium of educators and industry

EDUCATIONAL RESOURCES
FOR THE
MACHINE TOOL INDUSTRY



Manufacturing Technology Series

INSTRUCTOR'S HANDBOOK
DUTIES F THROUGH L

Supported by the National Science Foundation's Advanced Technological Education Program

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MFG FM4
[illegible]

MFG-F1

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-F1

Subject: **Manufacturing Technology** **Time: 4 Hrs.**

Duty: **Perform Conventional Machining**
Task: Prepare and Plan For Machining Operations

Objective(s):

Upon completion of this unit the student will be able to:
a. Read and interpret blueprints;
b. Understand machinability and chip formation;
c. Use the *Machinery's Handbook* as a reference for machine applications;
d. Describe the tools and toolholders will be needed for machining operations;
e. Calculate speeds, feeds, and depth of cut for various machine operations;
f. Use carbides and other tool materials;
g. Assemble work holding (fixturing) components; and,
h. Perform basic semi-precision and precision layout as necessary.

Instructional Materials:

MASTER Handout (MFG-F1-HO)
MASTER Laboratory Aid (MFG-F1-LA)
MASTER Self-Assessment
Blueprints
Tools & tool materials
Fixturing components
Lay-out equipment

References:

Machinery's Handbook, Industrial Press, Latest Edition
NTMA Modules:

MA-I-03	"Blueprint Reading, Introduction"
MA-I-04	"Relative Motions Between Tool & Workpiece: Chip Formation"
MA-I-22	"Milling Machine: Speeds & Feeds/Problems"
MA-I-24	"Milling Machine: Cutters and Operations"
MA-I-32	"Engine Lathe: Cutting Tools & Fluids"

MA-I-34 "Engine Lathe: Accessories & Work Holding Devices"
MA-III-45, -49, -53, -57, -61, 65, -69, -73, -75, -77, and -79
MA-III-44, -48, -52, -56, -60, -64, and -68
"Carbide Tooling: *Assorted Topics*"

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1 through MFG-A7	"Practice Safety"
MFG-B1 through MFG-B15	"Apply Mathematical Concepts"
MFG-C1 through MFG-C10	"Interpret Engineering Drawings and Control Documents"
MFG-D1 through MFG-D6	"Recognize Different Manufacturing Materials and Processes"
MFG-E1 through MFG-E6	"Measure/Inspect"

Introduction:

Before any experienced machinist begins work on a machining job, he or she will take time to plan their work so that it can be performed in the most efficient manner. Time spent in the planning of the work and the preparation of the machine and/or tools and accessories will yield increased production, better quality parts, less scrap/re-work, and more time to concentrate on better surface finishes and tighter tolerances. Incidently, all of these things are things which are highly desirable and most rewarded by employers.

Presentation Outline:

I. Plan for Machining Operation
    A. Read and interpret blueprints
    B. Understand machinability and chip formation
    C. Use the *Machinery's Handbook* as a reference for machine applications
    D. Answer the following questions
        1. What operations are necessary to produce the part? (qualify, rough, finish, grind, face, turn, thread, groove, etc.)
        2. What sequence of tools will be used?
        3. How will the part be fixtured? Fasteners should not interfere with machine moves. (Clamps, vise, chucks, collets, etc.)
        4. How many set-ups will be required?
        5. What is the accuracy required for machining dimensions?
II. Prepare for Machining Operations
    A. What type of tools and toolholders will be needed for roughing, finishing, etc.? Use carbides and other tool materials when available. Verify tool availability.

B. Calculate speeds, feeds, and depth of cut for various machine operations
C. Assemble work holding (fixturing) components
D. Perform basic semi-precision and precision layout as necessary
E. Load the part into the workholding (fixturing) device

Practical Application:

Given a blueprint, the student will design a process plan for fabricating the parts.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-F2) dealing with the selection and use of hand tools.

MFG-F1-HO
Prepare and Plan for Machining Operations
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Read and interpret blueprints;
- b. Understand machinability and chip formation;
- c. Use the *Machinery's Handbook* as a reference for machine applications;
- d. Describe the tools and toolholders will be needed for machining operations;
- e. Calculate speeds, feeds, and depth of cut for various machine operations;
- f. Use carbides and other tool materials;
- g. Assemble work holding (fixturing) components; and,
- h. Perform basic semi-precision and precision layout as necessary.

Module Outline:

- I. Plan for Machining Operation
  - A. Read and interpret blueprints
  - B. Understand machinability and chip formation
  - C. Use the *Machinery's Handbook* as a reference for machine applications
  - D. Answer the following questions
    - 1. What operations are necessary to produce the part? (qualify, rough, finish, grind, face, turn, thread, groove, etc.)
    - 2. What sequence of tools will be used?
    - 3. How will the part be fixtured? Fasteners should not interfere with machine moves. (Clamps, vise, chucks, collets, etc.)
    - 4. How many set-ups will be required?
    - 5. What is the accuracy required for machining dimensions?
- II. Prepare for Machining Operations
  - A. What type of tools and toolholders will be needed for roughing, finishing, etc.? Use carbides and other tool materials when available. Verify tool availability.
  - B. Calculate speeds, feeds, and depth of cut for various machine operations
  - C. Assemble work holding (fixturing) components
  - D. Perform basic semi-precision and precision layout as necessary
  - E. Load the part into the workholding (fixturing) device

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name______________________________ Date_________________

MFG-F1
Prepare and Plan For Machining Operations
Self-Assessment

Circle the letter preceding the correct answer.

1. The intentional difference in the sizes of mating parts is called _______________ .
   A. Fit
   B. Tolerance
   C. Allowance
   D. Limits

2. The permissible variation of the size of a part is called _________________ .
   A. Fit
   B. Tolerance
   C. Allowance
   D. Limits

3. The largest and smallest permissible dimensions of a part are the _______________ .
   A. Fit
   B. Tolerance
   C. Allowance
   D. Limits

4. Which property of metals is directly related to machinability?
   A. Ductility
   B. Malleability
   C. Hardness
   D. Elasticity

5. Which of the following types of information can not be found in the *Machinery's Handbook*?
   A. Recommended cutting speeds
   B. Recommended feeds
   C. Table of composition of steels
   D. Table of machine tool builders

6. The RPM for machining a 1" diameter aluminum workpiece (SFM=500) is______________ .
   A. 1000 RPM
   B. 2000 RPM
   C. 3000 RPM
   D. 4000 RPM

7. Using the ASA system of identifying carbide inserts, an insert with the number of TNMG-323E; what does the "T" indicate?
   A. Thickness
   B. Toughness
   C. The shape
   D. Two sided

8. Which type of inserts are best suited for machining extremely hard workpieces?
   A. Carbide
   B. Cemented oxide (ceramic)
   C. Cubic boron nitride
   D. Diamond

9. The ________________ may be used to measure or mark off vertical distances.
   A. Surface gage
   B. Vernier height gage
   C. Steel rule
   D. Craftsman's vertical scribe

10. Which of the following is usually used to lay out arcs and circles?
   A. Circle template
   B. Radius gages
   C. Sine bar
   D. Dividers

MFG-F1
Prepare and Plan for Machining Operations
Self-Assessment Answer Key

1. C
2. B
3. D
4. C
5. D
6. B
7. C
8. D
9. B
10. D

MFG-F2

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-F2

Subject: **Manufacturing Technology** **Time: 12 Hrs.**

Duty: **Perform Conventional Machining**
Task: Use Hand Tools

Objective(s):

Upon completion of this unit the student will be able to:
- a. Select and use hand tools;
- b. Select and use hand files;
- c. Correctly identify and use hand taps and dies as required;
- d. Select and use hand reamers;
- e. Use arbor and shop presses; and,
- f. Perform off-hand grinding operations.

Instructional Materials:

MASTER Handout (MFG-F2-HO)
MASTER Laboratory Exercise (MFG-F2-LE)
MASTER Laboratory Aid (MFG-F2-LA)
MASTER Self-Assessment
Each student should have access to any of the hand tools which will be covered during this module.
Each student will also need to have some type of workbench with a bench vise securely mounted to the it.

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Hand Tools"
Workbook for Machining Fundamentals, From Basic to Advanced Techniques, John R. Walker, The Goodheart-Willcox Co., Inc., Publishers, Latest Edition
NTMA Modules:
  MA-I-33 "Noncutting Handtools"
  MA-I-35 "Cutting Handtools"

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-F1 “Prepare and Plan For Machining Operations”

Introduction:

One of the most important aspects of the machinist trade involves the use of hand tool operations or bench work. This may refer to operations such as laying out, fitting, and assembling. The machinist is often expected to saw, file, polish, ream, and thread using only hand tools. So the ability to select and properly use hand tools is very important and require continued practice by the machinist to master these skills.

Presentation Outline:

I. Select and Use Hand Tools
    A. Bench vise
    B. Clamps
    C. Pliers
    D. Hammers
    E. Wrenches
    F. Screwdrivers
    G. Chisels and punches
    H. Hacksaws
II. Select and Use Hand Files
    A. Types of files
        1. Mill file
        2. Long angle (lathe) file
        3. Bastard files
    B. Shapes of files
        1. Pillar files
        2. Square files
        3. Warding files
        4. Knife files
        5. Three-square files
        6. Half-found files
        7. Round files
    C. Specialty files
        1. Swiss pattern files
        2. Die sinker’s rifflers
        3. Curved tooth files
        4. Thread files
        5. Rotary files and burrs
        6. Scrapers
    D. Care and use of files
        1. Proper care of files
        2. Proper use of files

            a. Cross filing
            b. Draw filing
    E. Student filing practice

III. Correctly Identify and Use Hand Taps and Dies as Required
    A. Identification of taps
        1. Identifying marks on inch taps (example: ½-13-UNC)
            a. Nominal size = ½"
            b. Threads per inch = 13
            c. Standardized thread series = Unified National Coarse
        2. Identifying marks on metric taps (example: M4 X 0.7)
            a. M = metric thread
            b. Nominal diameter of the thread = 4mm
            c. Pitch of the thread = 0.7mm
        3. Standard taps
            a. Taper (starting) taps
            b. Plug taps
            c. Taper taps
        4. Special taps
            a. Pipe taps
            b. Pulley taps
            c. Acme thread taps
    B. Care and use of taps
        1. Proper care of hand taps
        2. Determining tap drill size
            a. Tap drill size chart
            b. Tap drill size formula for inch taps
               Tap Drill Size = Major Diameter of the Tap minus 1 divided by the number of threads per inch
            c. Tap drill size formula for metric taps
               Tap Drill Size = major diameter (mm) minus the pitch (mm)
        3. Demonstrate proper use of hand taps
        4. Broken tap removal
            a. Tap extractor
            b. Acid
            c. Electrical discharge
    C. Identification and use of threading dies
        1. Solid die - for chasing or recutting damaged threads
        2. Adjustable split die - for cutting threads over or under the standard depth of thread
        3. Adjustable screw plate die - most efficient type of adjustable die for cutting external threads
    D. Student tap and die practice

IV. Select and Use Hand Reamers

- A. Types of hand reamers
  - 1. Straight fluted reamers
  - 2. Spiral fluted reamers
  - 3. Expansion reamers
  - 4. Adjustable hand reamers
  - 5. Taper reamers
- B. Care and Use of Hand Reamers
  - 1. Proper care of hand reamers
  - 2. Proper use of hand reamers
- C. Student hand reaming practice

V. Perform Finishing Processes
- A. Broaching
- B. Lapping
- C. Polishing

VI. Use Arbor and Shop Presses
- A. To install bushings/bearings
- B. To press shafts in and out of gears and sprockets
- C. To seat mandrels
- D. To broach keyways
- E. To bend and straighten

VII. Perform Off-Hand Grinding Operations
- A. Setting up the grinder (demonstration)
  - 1. Grinding wheel selection
  - 2. Grinding wheel "ring test"
  - 3. Mounting the grinding wheel
  - 4. Tool rest adjustment
  - 5. Dressing the grinding wheel
- B. Perform off-hand grinding exercises (demonstration)
  - 1. Sharpen a flat blade screwdriver
  - 2. Sharpen a cold chisel
  - 3. Grind/Sharpen a high speed cutting bit
- C. Student practice of grinding exercises

Practical Application:

Students will begin making a Drill/Hole Gage to be finished in MFG-F4.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-F3) dealing with the operation of power saws.

MFG-F2-HO
Use Hand Tools
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

- **a. Select and use hand tools;**
- **b. Select and use hand files;**
- **c. Correctly identify and use hand taps and dies as required;**
- **d. Select and use hand reamers;**
- **e. Use arbor and shop presses; and,**
- **f. Perform off-hand grinding operations.**

Module Outline:

- I. Select and Use Hand Tools
  - A. Bench vise
  - B. Clamps
  - C. Pliers
  - D. Hammers
  - E. Wrenches
  - F. Screwdrivers
  - G. Chisels and punches
  - H. Hacksaws
- II. Select and Use Hand Files
  - A. Types of files
    - 1. Mill file
    - 2. Long angle (lathe) file
    - 3. Bastard files
  - B. Shapes of files
    - 1. Pillar files
    - 2. Square files
    - 3. Warding files
    - 4. Knife files
    - 5. Three-square files
    - 6. Half-found files
    - 7. Round files
  - C. Specialty files
    - 1. Swiss pattern files
    - 2. Die sinker's rifflers
    - 3. Curved tooth files
    - 4. Thread files
    - 5. Rotary files and burrs

    - 6. Scrapers
  - D. Care and use of files
    - 1. Proper care of files
    - 2. Proper use of files
      - a. Cross filing
      - b. Draw filing
  - E. Student filing practice
- III. Correctly Identify and Use Hand Taps and Dies as Required
  - A. Identification of taps
    - 1. Identifying marks on inch taps (example: ½-13-UNC)
      - a. Nominal size = ½"
      - b. Threads per inch = 13
      - c. Standardized thread series = Unified National Coarse
    - 2. Identifying marks on metric taps (example: M4 X 0.7)
      - a. M = metric thread
      - b. Nominal diameter of the thread = 4mm
      - c. Pitch of the thread = 0.7mm
    - 3. Standard taps
      - a. Taper (starting) taps
      - b. Plug taps
      - c. Taper taps
    - 4. Special taps
      - a. Pipe taps
      - b. Pulley taps
      - c. Acme thread taps
  - B. Care and use of taps
    - 1. Proper care of hand taps
    - 2. Determining tap drill size
      - a. Tap drill size chart
      - b. Tap drill size formula for inch taps
        Tap Drill Size = Major Diameter of the Tap minus 1 divided by the number of threads per inch
      - c. Tap drill size formula for metric taps
        Tap Drill Size = major diameter (mm) minus the pitch (mm)
    - 3. Demonstrate proper use of hand taps
    - 4. Broken tap removal
      - a. Tap extractor
      - b. Acid
      - c. Electrical discharge
  - C. Identification and use of threading dies
    - 1. Solid die - for chasing or recutting damaged threads
    - 2. Adjustable split die - for cutting threads over or under the standard depth of thread

        3. Adjustable screw plate die - most efficient type of adjustable die for cutting external threads
    D. Student tap and die practice
IV. Select and Use Hand Reamers
    A. Types of hand reamers
        1. Straight fluted reamers
        2. Spiral fluted reamers
        3. Expansion reamers
        4. Adjustable hand reamers
        5. Taper reamers
    B. Care and Use of Hand Reamers
        1. Proper care of hand reamers
        2. Proper use of hand reamers
    C. Student hand reaming practice
V. Perform Finishing Processes
    A. Broaching
    B. Lapping
    C. Polishing
VI. Use Arbor and Shop Presses
    A. To install bushings/bearings
    B. To press shafts in and out of gears and sprockets
    C. To seat mandrels
    D. To broach keyways
    E. To bend and straighten
VII. Perform Off-Hand Grinding Operations
    A. Setting up the grinder (demonstration)
        1. Grinding wheel selection
        2. Grinding wheel "ring test"
        3. Mounting the grinding wheel
        4. Tool rest adjustment
        5. Dressing the grinding wheel
    B. Perform off-hand grinding exercises (demonstration)
        1. Sharpen a flat blade screwdriver
        2. Sharpen a cold chisel
        3. Grind/Sharpen a high speed cutting bit
    C. Student practice of grinding exercises

MFG-F2-LE
Use Hand Tools
Attachment 2: MASTER Laboratory Exercise

For this exercise, you will make a drill/hole gage.

Necessary Equipment:

- 1/8" x 2" x 8" steel bar (cold finish)
- 3/4" radius gage
- File, Double cut
- File, single cut
- Hacksaw
- Layout tools
- Steel Rule for straight edge
- Vise

I. Layout
  - A. Scribe the cutting lines.
  - B. Scribe the hole centers.
  - C. Center punch the hole centers.

II. Cutting
  - A. Leave a 1/32" lip on each cut. This lip will be filed off to finish the tool.
  - B. Make sure that the workpiece is firmly in the vise and that the clearance is sufficient to allow cutting.
  - B. Cut the 30° angle. Make certain that you do not cut into the body of your tool.
  - C. Cut the interior edge. Make sure that you do not cut into the lip rule of your tool.

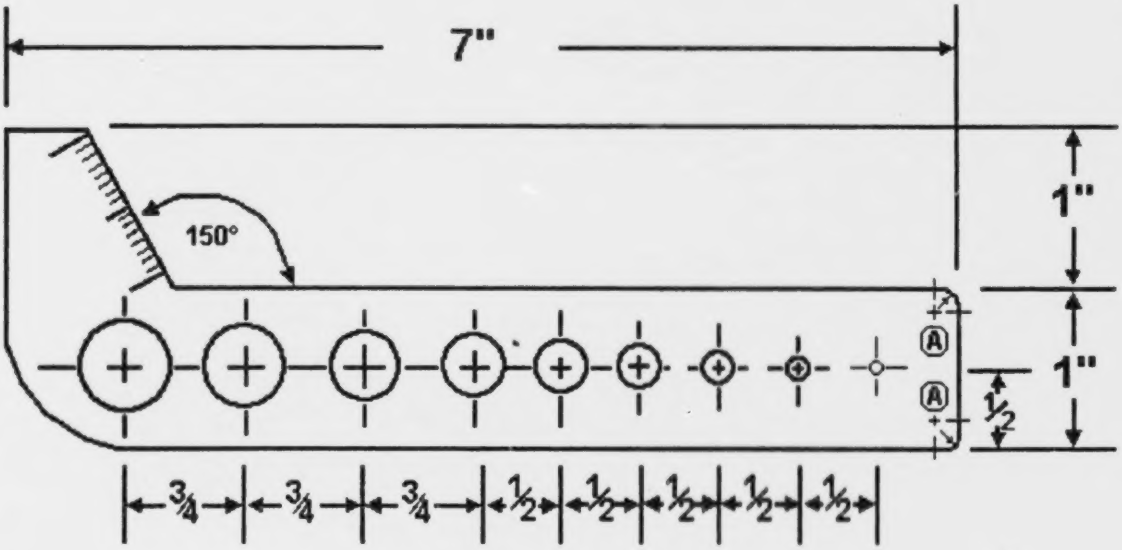
III. Filing
  - A. Straight surface's
    - 1. Using a single cut file, draw file all straight edges.
    - 2. Check the smoothness with the steel rule by holding the steel rule along one edge and looking toward a light.
    - 3. Continue filing the edge until almost no light is visible between the rule and the gage.
  - B. 3/4" radius
    - 1. Clamp the workpiece securely in the vise.
    - 2. Using the double cut file, file off the corner, leaving a 1/32" lip for finishing.
    - 3. Using the single cut file, round the corner by filing forward and downward.
    - 4. Frequently check the finish with the 3/4" radius gage.

IV. Scribing the lip gage

A. The 30° edge should be marked at 1/16" intervals.
B. Ensure that all lines are parallel.
C. Scribe them into the edge by the method recommended by your instructor.

All Holes Bored Through
Hole Sites:
Left-to-Right
9/16"
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
1/8"
1/16"

Ⓐ 1/4" radius round



MFG-F2-LA
Use Hand Tools
Attachment 3: MASTER Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name______________________ Date____________

MFG-F2
Use Hand Tools
Self-Assessment

Circle the letter preceding the correct answer.

1. To avoid failures from seizing when pressing a shaft or mandrel, you should ______________.
   - A. apply high pressure lubricant to the bore and shaft
   - B. use sulfurized cutting oil on both parts
   - C. use a good grade of lubricating oil on both parts and don't stop after you start pressing
   - D. press them together dry

2. C-clamps are mostly used by the machinist for ______________.
   - A. holding delicate measuring and layout setups
   - B. clamping workpieces on the bench for filing and sawing
   - C. clamping workpieces on machines such as drill presses
   - D. holding vises on milling machines and drill presses

3. Parallel clamps are mostly used for ______________.
   - A. holding delicate measuring and layout setups
   - B. clamping workpieces on the bench for filing and sawing
   - C. clamping workpieces on machines such as drill presses
   - D. holding vises on milling machines and drill presses

4. The pitch of a hacksaw blade is the same as the ______________.
   - A. set of the blade
   - B. thickness of the blade
   - C. number of teeth per inch
   - D. kerf cut by a blade

5. A mill file is ______________.
   - A. square
   - B. milled
   - C. double cut
   - D. single cut

6. The edge on a file without teeth is called a ______________.
   - A. straight edge
   - B. safe edge
   - C. smooth edge
   - D. flat edge

7. Hand reamers can be readily identified by the ________________.
   A. length of the flutes
   B. length of the body
   C. markings on the shank
   D. square on the shank

8. To make a hole .002" larger than a nominal size, you should ________________.
   A. drill with a twist drill
   B. wiggle the reamer slightly in the hole
   C. ream with an expansion reamer
   D. use a spiral flute reamer

9. The size of the tap drill is important because it ________________.
   A. determines the size of the thread
   B. regulates the percentage of thread
   C. forms the major diameter
   D. determines the depth of the hole

10. A tap has the markings 7/8-9-NC on its shank. What does the 9 represent?
   A. the major diameter of the tap
   B. the minor diameter of the tap
   C. the length of the tap
   D. the number of threads per inch

MFG-F2
Use Hand Tools
Self-Assessment Answer Key

1. A

2. C

3. A

4. C

5. D

6. B

7. D

8. C

9. B

10. D

MFG-F3

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-F3

Subject: **Manufacturing Technology** **Time: 16 Hrs.**

Duty: **Perform Conventional Machining**
Task: Operate Power Saws

Objective(s):

Upon completion of this unit the student will be able to:
a. Use reciprocating and horizontal band cutoff machines;
b. Operate abrasive and cold saws; and,
c. Setup and use the vertical band saw.

Instructional Materials:

MASTER Handout (MFG-F3-HO)
MASTER Laboratory Exercise 1 (MFG-F3-LE1)
MASTER Laboratory Exercise 2 (MFG-F3-LE2)
MASTER Laboratory Aid (MFG-F3-LA)
MASTER Self-Assessment
The following items are necessary for the presentation of this lesson:
Safety glasses with side shields
Face shields
Steel measuring tape
Layout dye and scribes
Power hacksaw with blades
Horizontal bandsaw with blades, vise and work stand
Abrasive cutoff saw
Vertical contour bandsaw, blades and accessories
Various bar stock and flat metals for student practice

References:

NTMA Modules:

MA-I-08	"Saws and Sawing: General Information"
MA-II-02	"Sawing: Terminology"
MA-II-04	"Sawing: Power Hacksaws and Bandsaws"
MA-II-06	"Sawing: Practices"
MA-II-08	"Sawing: Blade Preparation and Circular Saws"

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-A3 "Follow Safe Operating Procedures for Hand and Machine Tools"

Introduction:

One of the most basic types of machine shop equipment is the category of power saws. The machinist will need to be very familiar with the setup and operation of all of the types of saws commonly found in the machine shop. Power saws fall into two classifications: cutoff saws and the contour bandsaw. This lesson discusses the topics which pertain to the blade selection, setting of blade surface feet per minute and safe operation of these saws.

Presentation Outline:

I. Cutoff Type Metal Saws
  A. Four types of cutoff saws
    1. Power hacksaw - reciprocating type which cuts only on the forward stroke. It is not generally considered to be one of the most efficient cutoff machines in the machine shop.
    2. Horizontal bandsaw - uses a flexible, continuous blade which cuts continuously. They are available in a wide variety of types and sizes and are popular because of their high production and versatility.
    3. Abrasive cutoff saw - cuts metal with a thin abrasive blade which revolves at a high speed. One of it's strengths is that it can easily cut hardened metal.
    4. Friction saw - uses a saw band (usually without teeth) which is run at a very high speed (10,000 to 25,000 sfm) and burns or melts it way through metal. Ideal for cutting thin sections of structural and honeycombed parts of machine or stainless steel.
  B. Types of saw blades
    1. Material - high-speed tungsten and high-speed molybdenum steel is used for saw blades. Power hacksaws have blades which are hardened throughout while flexible blades have only the saw teeth hardened.
    2. Pitch - pitch is the number of teeth per inch. When cutting thick materials choose a saw blade with a course pitch, such as 4-6 to allow for proper chip clearance and maximum bite. When cutting thin materials choose a saw blade with a fine pitch, such as 12-14. 10 pitch is considered to be a good general purpose blade. (***Rule:*** Always use a blade which will allow at least 2

teeth to be in contact with the work at all times to avoid tooth breakage.)

C. Blade removal and installation
   1. Always turn the electrical power off
   2. Use a brush to clean the areas (guides) through which the blade must pass
   3. Carefully release any blade tensioning device and remove the blade
   4. Select the correct blade for the cutting job at hand
   5. Install the blade with the teeth facing in the proper cutting direction
   6. Tighten the blade tensioning device checking that the blade is properly aligned and tensioned
   7. Quickly start and stop the saw to verify proper operation
   8. For saws which have adjustable speeds, set the proper cutting speed for the metal to be cut

D. Operation
   1. Check vise mounting for tightness and squareness to the cutting blade
   2. Place material in the vise (support long pieces with a floor stand)
   3. Lower the saw blade until it is close to the work
   4. Adjust any blade guides until they just clear the sides of the material to be cut
   5. Measure the part to be cut, allowing 1/16" or more for saw run-out
   6. Tighten the vise, check length measurement and turn the saw on

E. Sawing hints
   1. Never attempt to mount, measure, or remove work unless the saw is stopped
   2. Guard long material at both ends to prevent anyone from coming in contact with it
   3. Use cutting fluid when possible to help prolong the life of the saw blade
   4. When several pieces of the same length are to be cut, set the stop gage to the desired length
   5. If the blade dulls or breaks, re-start the cut in a new place

F. Student practice
   1. Students should select proper pitch blade for a cutting application
   2. Students should practice removal/installation of a saw blade
   3. Students should use the saw to cut a piece of metal to length
   4. Students should operate abrasive and cold saws if available

II. The Vertical Contour Bandsaw

A. Description of the contour bandsaw parts and accessories
    1. Base
    2. Column
    3. Head
B. Bandsaw Applications
    1. Notching
    2. Slotting
    3. Splitting
    4. Radius cutting
    5. Angular cutting
    6. Three-dimensional shaping
C. Blade Variables/Types (the text has excellent illustrations for each of these)
    1. Tooth forms -
        a. Precision or regular
        b. Claw or hook tooth
        c. Buttress or skip tooth
    2. Pitch - the number of teeth per inch (see above discussion at I,B,2)
    3. Set - amount of side to side offset of the teeth for clearance
        a. Wave
        b. Straight
        c. Raker
    4. Width - the distance from the tip of the teeth to the back of the blade
        a. For making straight cuts, select a wide blade
        b. For cutting small radii, select a narrow blade
        c. For general cutting, select the widest blade which can cut the smallest radius on the workpiece
    5. Gage - the thickness of the saw blade
D. Bandsaw operation
    1. Instructor demonstration of the following
        a. Blade removal/assembly
            1. Unfolding/folding saw blades
            2. Measuring and cutting stock saw blade material
            3. Welding a saw blade using the band welder
        b. Cutting speed adjustment
        c. Saw guide adjustments
        d. Careful operation of the bandsaw
    2. Student practice of the following steps
        a. Blade removal/assembly
            1. Unfolding/folding saw blades
            2. Measuring and cutting stock saw blade material
            3. Welding a saw blade using the band welder
        b. Cutting speed adjustment

    - c. Saw guide adjustments
    - d. Careful operation of the bandsaw
- III. Cleanup and Review of Main Lesson Points

Practical Application:

The students will work under instructor supervision to perform each of the tasks outlined in the lesson outline, in a safe, efficient manner.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson. In addition, students will use each of the machines discussed and cut pieces of material to a tolerance of ± 1/16".

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-F4) dealing with the operation of drill presses.

MFG-F3-HO
Operate Power Saws
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Use reciprocating and horizontal band cutoff machines;
- b. Operate abrasive and cold saws; and,
- c. Setup and use the vertical band saw.

Module Outline:

- I. Cutoff Type Metal Saws
  - A. Four types of cutoff saws
    - 1. Power hacksaw - reciprocating type which cuts only on the forward stroke. It is not generally considered to be one of the most efficient cutoff machines in the machine shop.
    - 2. Horizontal bandsaw - uses a flexible, continuous blade which cuts continuously. They are available in a wide variety of types and sizes and are popular because of their high production and versatility.
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  - B. Types of saw blades
    - 1. Material - high-speed tungsten and high-speed molybdenum steel is used for saw blades. Power hacksaws have blades which are hardened throughout while flexible blades have only the saw teeth hardened.
    - 2. Pitch - pitch is the number of teeth per inch. When cutting thick materials choose a saw blade with a course pitch, such as 4-6 to allow for proper chip clearance and maximum bite. When cutting thin materials choose a saw blade with a fine pitch, such as 12-14. 10 pitch is considered to be a good general purpose blade. (***Rule:*** Always use a blade which will allow at least 2 teeth to be in contact with the work at all times to avoid tooth breakage.)
  - C. Blade removal and installation
    - 1. Always turn the electrical power off

        2. Use a brush to clean the areas (guides) through which the blade must pass
        3. Carefully release any blade tensioning device and remove the blade
        4. Select the correct blade for the cutting job at hand
        5. Install the blade with the teeth facing in the proper cutting direction
        6. Tighten the blade tensioning device checking that the blade is properly aligned and tensioned
        7. Quickly start and stop the saw to verify proper operation
        8. For saws which have adjustable speeds, set the proper cutting speed for the metal to be cut
    D. Operation
        1. Check vise mounting for tightness and squareness to the cutting blade
        2. Place material in the vise (support long pieces with a floor stand)
        3. Lower the saw blade until it is close to the work
        4. Adjust any blade guides until they just clear the sides of the material to be cut
        5. Measure the part to be cut, allowing 1/16" or more for saw run-out
        6. Tighten the vise, check length measurement and turn the saw on
    E. Sawing hints
        1. Never attempt to mount, measure, or remove work unless the saw is stopped
        2. Guard long material at both ends to prevent anyone from coming in contact with it
        3. Use cutting fluid when possible to help prolong the life of the saw blade
        4. When several pieces of the same length are to be cut, set the stop gage to the desired length
        5. If the blade dulls or breaks, re-start the cut in a new place
    F. Student practice
        1. Students should select proper pitch blade for a cutting application
        2. Students should practice removal/installation of a saw blade
        3. Students should use the saw to cut a piece of metal to length
        4. Students should operate abrasive and cold saws if available
II. The Vertical Contour Bandsaw
    A. Description of the contour bandsaw parts and accessories
        1. Base
        2. Column
        3. Head

B. Bandsaw Applications
   1. Notching
   2. Slotting
   3. Splitting
   4. Radius cutting
   5. Angular cutting
   6. Three-dimensional shaping

C. Blade Variables/Types (the text has excellent illustrations for each of these)
   1. Tooth forms -
      a. Precision or regular
      b. Claw or hook tooth
      c. Buttress or skip tooth
   2. Pitch - the number of teeth per inch (see above discussion at I,B,2)
   3. Set - amount of side to side offset of the teeth for clearance
      a. Wave
      b. Straight
      c. Raker
   4. Width - the distance from the tip of the teeth to the back of the blade
      a. For making straight cuts, select a wide blade
      b. For cutting small radii, select a narrow blade
      c. For general cutting, select the widest blade which can cut the smallest radius on the workpiece
   5. Gage - the thickness of the saw blade

D. Bandsaw operation
   1. Instructor demonstration of the following
      a. Blade removal/assembly
         1. Unfolding/folding saw blades
         2. Measuring and cutting stock saw blade material
         3. Welding a saw blade using the band welder
      b. Cutting speed adjustment
      c. Saw guide adjustments
      d. Careful operation of the bandsaw
   2. Student practice of the following steps
      a. Blade removal/assembly
         1. Unfolding/folding saw blades
         2. Measuring and cutting stock saw blade material
         3. Welding a saw blade using the band welder
      b. Cutting speed adjustment
      c. Saw guide adjustments
      d. Careful operation of the bandsaw

III. Cleanup and Review of Main Lesson Points

MFG-F3-LE1
Operate Power Saws
Attachment 2: MASTER Laboratory Exercise No. 1

Laboratory Exercise No. 1:

1. Instructor will demonstrate how to setup and operate a band saw to a designated tolerance without endangering personnel or equipment by:
   A. Selecting proper blade;
   B. Installing and properly adjusting the blade;
   C. Adjusting the blade guides and guard;
   D. Adjusting the coolant flow if or as appropriate;
   E. Adjusting feed control (if applicable);
   F. Properly securing the work and making a cut to specified tolerances; and,
   G. Shutting down the machine and cleaning up work area.

2. Student will demonstrate how to setup and operate a band saw to a designated tolerance without endangering personnel or equipment by:
   A. Selecting proper blade;
   B. Installing and properly adjusting the blade;
   C. Adjusting the blade guides and guard;
   D. Adjusting the coolant flow if or as appropriate;
   E. Adjusting feed control (if applicable);
   F. Properly securing the work and making a cut to specified tolerances; and,
   G. Shutting down the machine and cleaning up work area.

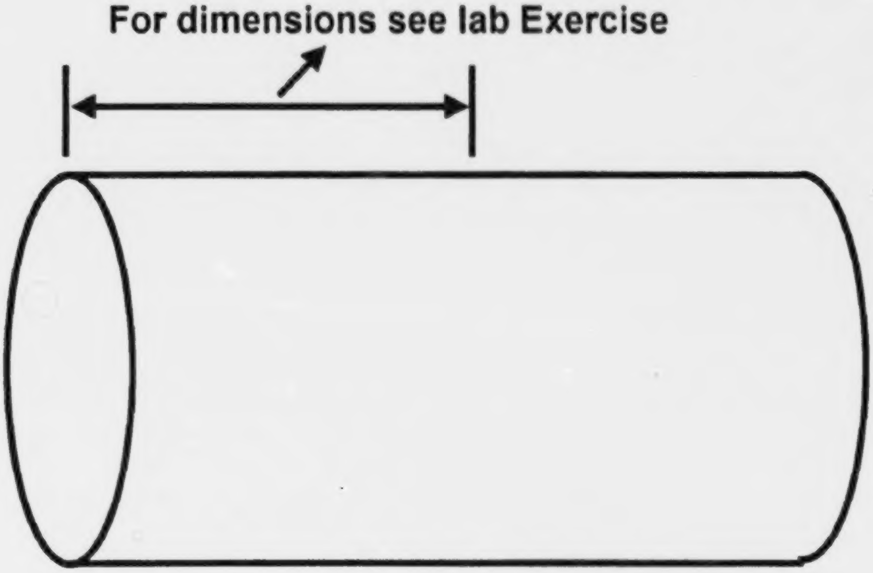
3. Instructor will grade student's performance.

Laboratory Exercise No. 2:

Using each of the saws discussed in the module, the student will cut five workpieces, in different metals or grades of steel. The required accuracy is +/-1/16".

The following five lengths should be cut by each student:

1. 4"
2. 2.5"
3. 40 mm
4. 5 1/8"
5. 50 mm



MFG-F3-LA
Operate Power Saws
Attachment 4: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name______________________________ Date________________

MFG-F3
Operate Power Saws
Self-Assessment

Circle the letter preceding the correct answer.

1. Which of the following is *not* normally classified as a cutoff saw?
   - A. Horizontal bandsaw
   - B. Contour bandsaw
   - C. Power hacksaw
   - D. Abrasive saw

2. Which type of saw is most productive when preparing bar stock for machining operations?
   - A. Horizontal bandsaw
   - B. Contour bandsaw
   - C. Power hacksaw
   - D. Abrasive saw

3. Which type of saw is most useful for sawing parts having unusual angles and radii?
   - A. Horizontal bandsaw
   - B. Contour bandsaw
   - C. Power hacksaw
   - D. Abrasive saw

4. Which of the following refers to the number of teeth per inch for a saw blade?
   - A. Set
   - B. Gage
   - C. TPI
   - D. Pitch

5. Using your answer to question 4, which is best for general purpose sawing?
   - A. 4
   - B. 6
   - C. 10
   - D. 14

6. Which type of sawing can be done using a blade with no teeth?
   - A. Precision
   - B. Soft materials
   - C. Abrasive
   - D. Friction

7. What happens if too fast a blade speed is used?
   - A. You finish the job sooner
   - B. You burn up the saw blade
   - C. You increase production
   - D. You injure yourself

8. What do you do if the saw blade dulls or breaks before the cut is completed?
   - A. Stop the saw
   - B. Replace the blade with a new one
   - C. Re-start the cut in a new location
   - D. All of the above

9. How is the blade speed adjusted on a contour bandsaw?
   - A. Change the belts
   - B. Change the blade
   - C. Adjust the handwheel
   - D. Adjust the blade supports and guides

10. Which of the following is *not* a requirement of a sawing job?
    - A. Speed
    - B. Safety
    - C. Tool life
    - D. Accuracy

MFG-F3
Operate Power Saws
Self-Assessment Answer Key

1. B
2. A
3. A
4. D
5. C
6. D
7. B
8. D
9. C
10. A

MFG-F4

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-F4

Subject: **Manufacturing Technology** **Time: 20 Hrs.**

Duty: **Perform Conventional Machining**
Task: Operate Drill Presses

Objective(s):

Upon completion of this unit the student will be able to:

a. Describe the different types of drill presses found in the machine shop;
b. Select and use the standard drilling machine accessories;
c. Select and use standard drilling tools;
d. Sharpen a drill bit using a bench or pedestal grinder; and,
e. Layout, setup and perform these drilling operations: drilling, tapping, countersinking, counterboring, reaming.

Instructional Materials:

MASTER Handout (MFG-F4-HO)
MASTER Laboratory Exercise No. 1 (MFG-F4-LE1)
MASTER Laboratory Exercise No. 2 (MFG-F4-LE2)
MASTER Laboratory Aid (MFG-F4-LA)
MASTER Self-Assessment
The following items are necessary for the presentation of this lesson:
Safety glasses for each student
Drill presses (with tool holding & work holding devices)
Twist drills, taps, reamers with accessories
Various sizes & shapes of different metals for student practice

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References:

NTMA Modules:

MA-I-10	"Drill Press: General Information"
MA-I-12	"Drill Press: Drill Bits"
MA-I-14	"Drill Press: Reamers & Drilling Operations"

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-F1	"Prepare and Plan For Machining Operations"
MFG-F2	"Use Hand Tools"

Introduction:

One of the most important machines that the machinist may be called on to operate is a drilling machine. The principle of a rotating tool producing a hole in a workpiece is very basic to all machine operations. Not only are drill presses used to produce holes, but they are also capable of threading, countersinking, reaming, boring, counterboring, and many other operations necessary for the production of goods in American industry today. Many entry-level machine operators and machinists will find their first job to be that of a drill press operator.

Presentation Outline:

I. Describe the Different Types of Drill Presses Found in the Machine Shop
  A. Sensitive drill press
  B. Upright drill press
  C. Radial drill press
  D. CNC drilling machines
II. Select and Use the Standard Drilling Machine Accessories
  A. Tool-holding devices
    1. Drill chucks
    2. Drill sockets, sleeves and drifts
  B. Work-holding devices
    1. Drill vise
    2. V-blocks
    3. Angle plate
    4. Clamps and straps
III. Select and Use Standard Drilling Tools
  A. Twist drills
    1. Shank
    2. Body
    3. Points
    4. Sizes
      a. Fractional size drills
      b. Number size drills
      c. Letter size drills
      d. Metric drills
    5. Special types of drills
      a. Straight-fluted
      b. Spade drills
      c. Deep hole drills
      d. Core drills
    6. Cutting fluids
      a. Drilling
      b. Tapping

- B. Sharpen a drill bit using a bench or pedestal grinder
  - 1. Review grinder safety
  - 2. Discuss the following drill point characteristics
    - a. Chisel edge
    - b. Lip clearance
    - c. Lip length
    - d. Web thinning
  - 3. Demonstrate this for the students
  - 4. Student practice

IV. Layout, Setup and Perform These Drilling Operations:

- A. Drilling
  - 1. Speed (rpm) - discuss the formula.....CS X 4 ÷ diam. = RPM
  - 2. Feed (inch per revolution) - roughing and finishing
- B. Countersinking
- C. Counterboring
- D. Reaming
  - 1. Discuss reaming allowance
  - 2. Speed is normally twice that used for drilling
  - 3. Feed is normally ½ that used for drilling
- E. Tapping
  - 1. Discuss tap drill size
  - 2. Discuss special taps for machine tapping

Practical Application:

Students will successfully complete the drill press exercises required for this module's laboratory exercises. Several exercises may be found in the student workbook, or the instructor may develop special activities which will utilize the resources for a given laboratory or for a given level of students (beginning, intermediate or advanced).

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-F5) dealing with the setup and operation of the vertical milling machine.

MFG-F4-HO
Operate Drill Presses
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Describe the different types of drill presses found in the machine shop;
- b. Select and use the standard drilling machine accessories;
- c. Select and use standard drilling tools;
- d. Sharpen a drill bit using a bench or pedestal grinder; and,
- e. Layout, setup and perform these drilling operations: drilling, tapping, countersinking, counterboring, reaming.

Module Outline:

- I. Describe the Different Types of Drill Presses Found in the Machine Shop
  - A. Sensitive drill press
  - B. Upright drill press
  - C. Radial drill press
  - D. CNC drilling machines
- II. Select and Use the Standard Drilling Machine Accessories
  - A. Tool-holding devices
    - 1. Drill chucks
    - 2. Drill sockets, sleeves and drifts
  - B. Work-holding devices
    - 1. Drill vise
    - 2. V-blocks
    - 3. Angle plate
    - 4. Clamps and straps
- III. Select and Use Standard Drilling Tools
  - A. Twist drills
    - 1. Shank
    - 2. Body
    - 3. Points
    - 4. Sizes
      - a. Fractional size drills
      - b. Number size drills
      - c. Letter size drills
      - d. Metric drills
    - 5. Special types of drills
      - a. Straight-fluted
      - b. Spade drills
      - c. Deep hole drills

    - d. Core drills
  - 6. Cutting fluids
    - a. Drilling
    - b. Tapping
- B. Sharpen a drill bit using a bench or pedestal grinder
  - 1. Review grinder safety
  - 2. Discuss the following drill point characteristics
    - a. Chisel edge
    - b. Lip clearance
    - c. Lip length
    - d. Web thinning
  - 3. Demonstrate this for the students
  - 4. Student practice

IV. Layout, Setup and Perform These Drilling Operations:

- A. Drilling
  - 1. Speed (rpm) - discuss the formula.....CS X 4 ÷ diam. = RPM
  - 2. Feed (inch per revolution) - roughing and finishing
- B. Countersinking
- C. Counterboring
- D. Reaming
  - 1. Discuss reaming allowance
  - 2. Speed is normally twice that used for drilling
  - 3. Feed is normally ½ that used for drilling
- E. Tapping
  - 1. Discuss tap drill size
  - 2. Discuss special taps for machine tapping

Laboratory Exercise No. 1:

Each student will be assigned two workpieces, made of either two different metals or two greatly different grades of steel.

1. For the first piece, the student will drill, ream, *counterbore*, and tap the following holes:
   - A. 3/16"
   - B. 1/2"
   - C. 5/8"
   - D. 4mm
   - E. 12mm

2. For the second piece, the student will drill, ream, *countersink*, and tap the following holes:
   - A. 3/16"
   - B. 1/2"
   - C. 5/8"
   - D. 4mm
   - E. 12mm

Laboratory Exercise No. 2:

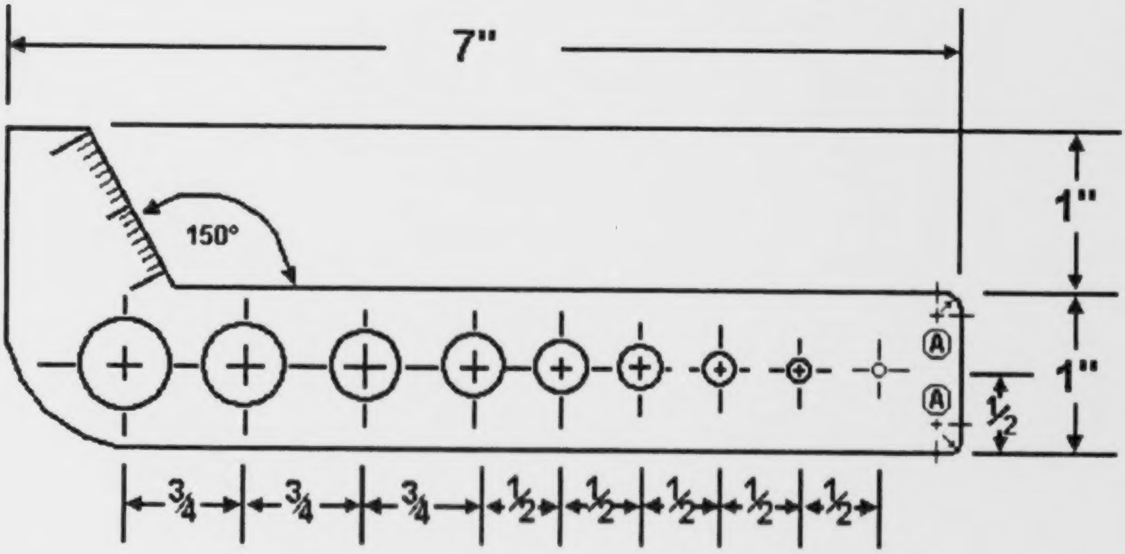
You will now complete your Drill/Hole Gage.

Necessary Equipment:
- #2 Center Drill
- Countersinks of appropriate sizes
- Drill Bits: 9/16", 1/2", 7/16", 3/8", 5/16", 1/4", 3/16", 1/8", 1/16"
- Set of Parallels
- Vise

I. Test the drill bits which you will use. Sharpen them as necessary.
II. Set up the gage and the parallels in the vise so that the 3/4" bit will clear through the gage.
III. With the machine OFF, emplace the center drill. The drill should be centered for the 3/4" hole.
IV. *Without moving the workpiece,* tighten the vise.
V. Drilling
    A. Set the machine to the correct speed for the drill size you are using.
    B. Spot drill all the holes *except* the 1/16" hole. (Spot drilling this hole may cause it to be over size in the finished tool).
    C. Change to the 1/16" bit and drill the hole.
    D. Change to the 1/8" bit and drill that hole. Using the 1/8" bit, pilot drill all larger holes.
    E. Drill the other holes.
    F. Be sure to check the machine speed for each drill size. Adjust the machine speed as necessary.
VI. Countersink each side of each hole. A minimal chamfer is all that is required.

All Holes Bored Through
Hole Sites:
Left-to-Right
9/16"
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
1/8"
1/16"

Ⓐ 1/4" radius round


7"
1"
1"
150°
Ⓐ
Ⓐ
½
¾
¾
¾
½
½
½
½
½

MFG-F4-LA
Operate Drill Presses
Attachment 4: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name______________________________ Date_________________

MFG-F4
Operate Drill Presses
Self-Assessment

Circle the letter preceding the correct answer.

1. Which of the following types of drill presses would be best suited for high volume production parts?
   - A. CNC drilling machine
   - B. sensitive drill press
   - C. radial drill press
   - D. gang drilling machine

2. Taper shank twist drills are mounted in the drill press using a __________________.
   - A. drill spindle
   - B. drill sleeve
   - C. drill socket
   - D. all of the above

3. How is a tapered shank drill removed from a drill press spindle?
   - A. with a reversible drill socket
   - B. with a drill drift
   - C. with a ball peen hammer
   - D. with a spindle remover

4. A conventional drill point usually has an included angle of _______________.
   - A. 60°
   - B. 90°
   - C. 118°
   - D. 135°

5. Which of the following types of drill bits has a removable cutting bit?
   - A. a core drill
   - B. a gun drill
   - C. a spade drill
   - D. a variable size drill

6. When a drill bit shows excessive wear at the outer corners of the point, the problem will usually be _________________.
   - A. improper web thinning
   - B. cutting lips with unequal angles
   - C. excessive feed
   - D. excessive speed

7. When a drill bit produces a hole which is excessively oversize, the problem will usually be ________________.
   A. improper web thinning
   B. cutting lips with unequal angles
   C. cutting lips with unequal lengths
   D. excessive feed

8. To make it easier for a drill bit to do it's work, which of the following will help greatly?
   A. thin the web of the drill
   B. use coolant
   C. inspect the drill bit
   D. all of the above

9. Which of the following factors affect the rate of feed chosen for a job?
   A. the diameter of the drill
   B. the material of the workpiece
   C. the condition of the drilling machine
   D. all of the above

10. As a general rule; for holes up to ½" diameter, allow __________ for reaming and for holes over ½" diameter, allow __________ for reaming.
   A. 1/64" , 1/32"
   B. 1/32" , 1/64"
   C. .100" , .200"
   D. none of the above

11. Which of the following types of taps cannot be used with the drill press?
   A. a gun tap
   B. a spiral-fluted tap
   C. a hand tap
   D. a tap drill

12. Which of the following is not a valid system of drill sizing?
   A. fractional drills
   B. taper drills
   C. metric drills
   D. letter drills

MFG-F4
Operate Drill Press
Self-Assessment Answer Key

1. A
2. D
3. B
4. C
5. C
6. D
7. C
8. D
9. D
10. A
11. D
12. B

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-F5

Subject: **Manufacturing Technology** **Time: 40 Hrs.**

Duty: **Perform Conventional Machining**
Task: Operate Vertical Milling Machines

Objective(s):

Upon completion of this unit the student will be able to:

a. Demonstrate the use of all controls on the vertical milling machine;
b. Align the vertical milling machine head;
c. Select, align, and use workholding devices;
d. Select milling tool holders;
e. Select milling cutters;
f. Perform all standard vertical milling operations;
g. Bore a hole using the offset boring head;
h. Machine angles using sine bar and gage blocks;
i Machine keyways; and,
j. Setup and machine dovetails.

Instructional Materials:

MASTER Handout (MFG-F5-HO)
MASTER Laboratory Exercise (MFG-F5-LE)
MASTER Laboratory Aid (MFG-F5-LA)
MASTER Self-Assessment
Vertical milling machine
Representative milling cutters, tool holders, etc.
Samples of metals to be milled

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Vertical Milling Machines"
Machinery's Handbook, Industrial Press, Latest Edition

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-A1 through MFG-A7 "Practice Safety"
MFG-B7 "Calculate Speeds and Feeds for Machining"

MFG-E3 "Measure With Hand Held Instruments"
MFG-F1 "Prepare and Plan For Machining Operations"

Introduction:

At less than 150 years in use, the highly versatile vertical mill is one of the newest of the conventional machine tools. The machine has really come into its own since the 1920's.

Presentation Outline:

- I. Identify Parts and Use All Controls on the Vertical Milling Machine
    - A. Base
    - B. Column
    - C. Knee
    - D. Saddle
    - E. Table
    - F. Ram
    - G. Toolhead
    - H. Motor
    - I. Turret Clamps
    - J. Quill, Quill Jack, and Spindle
    - K. Controls
        - 1. Forward/Reverse Motor Switch
        - 2. Spindle Brake
        - 3. Power Feed Change Lever
        - 4. Quill Feed Handwheel
        - 5. Feed Control Lever
        - 6. Quill Feed Hand Lever
        - 7. Feed Reverse Knob
        - 8. High/Low Speed Change Lever
        - 9. Variable Speed Control Wheel
        - 10. Table Reverse Crank
        - 11. Vertical Traverse Crank
        - 12. Cross Traverse Crank
        - 13. Table Power Feed
    - L. Locks and Gib Adjusting Screws
- II. Setup Milling Machine
    - A. Square the Toolhead to Table and Saddle Axes
    - B. Select, Align, and Use Workholding Devices
        - 1. Direct Table Mounting
        - 2. Mill Vises
        - 3. Work Edge and Hole Centerline Locating
    - C. Select Milling Tool Holders

        1. Solid Collet
        2. Split Collet
        3. Quick-Change Systems
        4. Arbor
    D. Select Milling Cutters
        1. High-Speed Steel Helical End Mills
        2. HSS Straight-Flute End Mills
        3. Carbide EMs
        4. Roughing and Tapering EMs
        5. Geometry-Forming EMs
        6. Dovetail EMs
        7. T-Slot EMs
        8. Woodruff Key EMs
        9. Shell End Mills
        10. Flycutters
VI. Perform All Standard Vertical Milling Operations
    A. Basic Operations and Terms
        1. Climb Milling vs Conventional Milling
        2. Factors Affecting Cutting Performance
        3. Cutting Fluids
            a. Purpose and Use
            b. Selection
            c. Safety
    D. Milling Cavities
    E. Angle Milling
    F. Drilling
VII. Bore a Hole Using the Offset Boring Head
    A. Identify Parts of Boring Head
    B. Workpiece Setup
    C. Tool Selection
    D. Use the Offset Boring Head
VIII. Machine Angles Using Sine Bar and Gage Blocks
    A. Identify Parts
        1. Sine Bar
        2. Sine Plate
        3. Use and Care of Gage Blocks
IX. Machine Keyways
X. Setup and Machine Dovetails and T-Slots

Practical Application:

Students will be able to perform the basic milling operations as demonstrated by the instructor. The student will identify all the parts of the machine, and the types of cutters and their uses.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-F6) dealing with the setup and operation of the horizontal milling machine.

MFG-F5-HO
Operate Vertical Milling Machines
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Demonstrate the use of all controls on the vertical milling machine;
b. Align the vertical milling machine head;
c. Select, align, and use workholding devices;
d. Select milling tool holders;
e. Select milling cutters;
f. Perform all standard vertical milling operations;
g. Bore a hole using the offset boring head;
h. Machine angles using sine bar and gage blocks;
i Machine keyways; and,
j. Setup and machine dovetails.

Module Outline:

I. Identify Parts and Use All Controls on the Vertical Milling Machine
   A. Base
   B. Column
   C. Knee
   D. Saddle
   E. Table
   F. Ram
   G. Toolhead
   H. Motor
   I. Turret Clamps
   J. Quill, Quill Jack, and Spindle
   K. Controls
      1. Forward/Reverse Motor Switch
      2. Spindle Brake
      3. Power Feed Change Lever
      4. Quill Feed Handwheel
      5. Feed Control Lever
      6. Quill Feed Hand Lever
      7. Feed Reverse Knob
      8. High/Low Speed Change Lever
      9. Variable Speed Control Wheel
      10. Table Reverse Crank
      11. Vertical Traverse Crank
      12. Cross Traverse Crank

    - 13. Table Power Feed
  - L. Locks and Gib Adjusting Screws
- II. Setup Milling Machine
  - A. Square the Toolhead to Table and Saddle Axes
  - B. Select, Align, and Use Workholding Devices
    - 1. Direct Table Mounting
    - 2. Mill Vises
    - 3. Work Edge and Hole Centerline Locating
  - C. Select Milling Tool Holders
    - 1. Solid Collet
    - 2. Split Collet
    - 3. Quick-Change Systems
    - 4. Arbor
  - D. Select Milling Cutters
    - 1. High-Speed Steel Helical End Mills
    - 2. HSS Straight-Flute End Mills
    - 3. Carbide EMs
    - 4. Roughing and Tapering EMs
    - 5. Geometry-Forming EMs
    - 6. Dovetail EMs
    - 7. T-Slot EMs
    - 8. Woodruff Key EMs
    - 9. Shell End Mills
    - 10. Flycutters
- VI. Perform All Standard Vertical Milling Operations
  - A. Basic Operations and Terms
    - 1. Climb Milling vs Conventional Milling
    - 2. Factors Affecting Cutting Performance
    - 3. Cutting Fluids
      - a. Purpose and Use
      - b. Selection
      - c. Safety
  - D. Milling Cavities
  - E. Angle Milling
  - F. Drilling
- VII. Bore a Hole Using the Offset Boring Head
  - A. Identify Parts of Boring Head
  - B. Workpiece Setup
  - C. Tool Selection
  - D. Use the Offset Boring Head
- VIII. Machine Angles Using Sine Bar and Gage Blocks
  - A. Identify Parts
    - 1. Sine Bar
    - 2. Sine Plate
    - 3. Use and Care of Gage Blocks

IX. Machine Keyways
X. Setup and Machine Dovetails and T-Slots

MFG-F5-LE
Operate Vertical Milling Machines
Attachment 2: MASTER Laboratory Exercise

I. The student should align the vertical milling machine head.

II. The student should mill the following forms:
  A. A keyseat in a shaft;
  B. A set of short (no more than 18") dovetail joints;
  C. A cavity in a block; and,
  D. A T-slot in a block 6" long; the T-slot must be parallel to the long side of the block.

III. Evaluation criteria:
  A. The chosen key must fit properly in the keyseat;
  B. The dovetailed workpieces must mate properly;
  C. The cavity in the block must be within the tolerances established by the instructor; and,
  D. The T-slot must accept and freely pass the selected commercial T-nut.

MFG-F5-LA
Operate Vertical Milling Machines
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name______________________________ Date________________

MFG-F5
Operate Vertical Milling Machines
Self-Assessment

Circle the letter preceding the correct answer.

1. The saddle is moved with the:
    - A. Cross traverse handle.
    - B. Vertical traverse crank.
    - C. Knee slide.
    - D. The saddle is immobile.
    - E. None of the above answers is correct.

2. The vertical mill's engine is located in the:
    - A. Base.
    - B. Column.
    - C. Toolhead.
    - D. Ram.
    - E. None of the above answers is correct.

3. The ball-end mill is used to cut:
    - A. Concave radii.
    - B. Convex radii.
    - C. Interior fillets.
    - D. Both A and C.
    - E. Both B and C.

4. T-slot cutters:
    - A. Are standard.
    - B. Fit standard T-*nuts*.
    - C. Cut the T-slots in machine tables and workholders.
    - D. All of the above answers are correct.
    - E. None of the above answers is correct.

5. An end mill holder is also called a:
    - A. Solid collet.
    - B. R-8 spindle.
    - C. Split collet.
    - D. Shell arbor.
    - E. None of the above answers is correct.

6. The major difficulty in using a split collet is:
   A. The looseness of the collet on the shank.
   B. The tendency of the tool to come out if the tool is turning too rapidly.
   C. The tool may pull out if the tool is dull.
   D. All of the above are problems involving split collets.
   E. None of the above answers is correct.

7. Machinist A says that the dovetail slide on the face of the column provides a guide for the knee. Machinist B says that single-angle milling cutters are used, usually in either 45° or 90° forms, to cut dovetails. Who is correct?
   A. Machinist A only
   B. Machinist B only
   C. Both machinists are correct.
   D. Neither machinist is correct.

8. Machinist A says that the flycutter is dangerous to use because the tool becomes almost invisible at high speed. Machinist B says that the flycutter, while not actually an end mill, is useful for making light face cuts on large areas. Who is correct?
   A. Machinist A only
   B. Machinist B only
   C. Both machinists are correct.
   D. Neither machinist is correct.

9. Some vertical mills are equipped with ___ jaws, used when it is necessary to shape the jaws to fit particular workpieces.
   A. Aluminum
   B. Tool steel
   C. Bronze
   D. Wrought iron
   E. None of the above answers is correct.

10. In *climb* or *down* milling, the cutter rotates ___ the feed; in *conventional* or *up* milling, the cutter rotates ___ the feed.
    A. Opposite to. . opposite to
    B. Opposite to. . .in the same direction as
    C. In the same direction as. . :opposite to
    D. In the same direction as. . .in the same direction as
    E. None of the above answers is correct.

MFG-F5
Operate Vertical Milling Machines
Self-Assessment Answer Key

1. A
2. C
3. D
4. D
5. A
6. C
7. A
8. C
9. A
10. C

MFG-F6

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-F6

Subject: **Manufacturing Technology** **Time: 32 Hrs.**

Duty: **Perform Conventional Machining**
Task: Operate Horizontal Milling Machines

Objective(s):

Upon completion of this unit the student will be able to:

a. Discuss the difference in plain and universal horizontal milling machines;
b. Discuss the types of spindles, arbors and adaptors used on the horizontal milling machine;
c. List several common work holding methods;
d. Use plain milling cutters;
e. Use side milling cutters; and,
f. Use face milling cutters.

Instructional Materials:

MASTER Handout (MFG-F6-HO)
MASTER Laboratory Exercise (MFG-F6-LE)
MASTER Laboratory Aid (MFG-F6-LA)
MASTER Self-Assessment

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, "Horizontal Milling Machines"

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1 through MFG-A7 "Practice Safety"
MFG-B7 "Calculate Speeds and Feeds for Machining"
MFG-E3 "Measure With Hand Held Instruments"
MFG-F1 "Prepare and Plan for Machining Operations"

Introduction:

The horizontal mill varies in size from small models found in almost all shops to huge machines the size of small buildings. As is evident from the huge differences in sizes of horizontal mills, they have a number of applications which cannot be adequately controlled by one person. The larger mills require teamwork to load their stock and to unload the finished parts. In situ inspections may also require more than one person to effectively and efficiently operate these titanic machines.

Presentation Outline:

I. Discuss the Difference in Plain and Universal Horizontal Milling Machines
    A. Determine Machine Size
    B. Identify Parts & Controls
        1. Base and Column
        2. Knee
        3. Saddle
        4. Table
        5. Spindle
        6. Overarm and Arbor Support
        7. Controls
            a. Manual movement controls
            b. Feed rate selector and feed engage
            c. Rapid traverse
            d. Spindle controls
            e. Locks
        8. Swivel housing on saddle of Universal Milling Machine
II. Discuss the Types of Spindles, Arbors, and Adaptors Used on the Horizontal Milling Machine
    A. Mill Spindle Tapers
    B. Arbors
        1. Style A
        2. Style B
        3. Style C
        4. Spacing Collars
        5. Bearing Collars
        6. Support Bearings
    C. Adapters
    D. Collets
    E. Quick-Change Systems
III. List Several Common Work Holding Methods
    A. Direct Table Mounts
        1. Clamp supports
        2. Screw jacks

- B. Mill Vises
- C. Miscellaneous Holders
    - 1. Rotary table
    - 2. Dividing head
    - 3. V-Blocks
    - 4. Specially made milling fixtures

IV. Use Plain Milling Cutters
- A. Roughing
- B. Squaring
- C. Milling Endpieces

V. Use Side Milling Cutters
- A. Setup
- B. Positioning the Cutter
- C. Making the Cut
    - 1. Keyseats
    - 2. Straddle and Gang Milling
- D. Helical Side Milling Cutters
    - 1. Uses
    - 2. Handedness

VI. Use Face Milling Cutters
- A. Composition and Inserts
- B. Uses
- C. Lead Angles and Rake Angles
- D. Wiper Flats

Practical Application:

Students shall be able to use the three types of cutters listed above; recognize and utilize the various spindles, arbors, and adaptors; and set up workpieces appropriately.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment and the Laboratory Exercise found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-F7) dealing with the setup and operation of a metal cutting engine lathe.

MFG-F6-HO
Operate Horizontal Milling Machines
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:
a. Discuss the difference in plain and universal horizontal milling machines;
b. Discuss the types of spindles, arbors and adaptors used on the horizontal milling machine;
c. List several common work holding methods;
d. Use plain milling cutters;
e. Use side milling cutters; and,
f. Use face milling cutters.

Module Outline:

I. Discuss the Difference in Plain and Universal Horizontal Milling Machines
  A. Determine Machine Size
  B. Identify Parts & Controls
    1. Base and Column
    2. Knee
    3. Saddle
    4. Table
    5. Spindle
    6. Overarm and Arbor Support
    7. Controls
      a. Manual movement controls
      b. Feed rate selector and feed engage
      c. Rapid traverse
      d. Spindle controls
      e. Locks
    8. Swivel housing on saddle of Universal Milling Machine
II. Discuss the Types of Spindles, Arbors, and Adaptors Used on the Horizontal Milling Machine
  A. Mill Spindle Tapers
  B. Arbors
    1. Style A
    2. Style B
    3. Style C
    4. Spacing Collars
    5. Bearing Collars
    6. Support Bearings

  - C. Adapters
  - D. Collets
  - E. Quick-Change Systems
- III. List Several Common Work Holding Methods
  - A. Direct Table Mounts
    - 1. Clamp supports
    - 2. Screw jacks
  - B. Mill Vises
  - C. Miscellaneous Holders
    - 1. Rotary table
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    - 3. V-Blocks
    - 4. Specially made milling fixtures
- IV. Use Plain Milling Cutters
  - A. Roughing
  - B. Squaring
  - C. Milling Endpieces
- V. Use Side Milling Cutters
  - A. Setup
  - B. Positioning the Cutter
  - C. Making the Cut
    - 1. Keyseats
    - 2. Straddle and Gang Milling
  - D. Helical Side Milling Cutters
    - 1. Uses
    - 2. Handedness
- VI. Use Face Milling Cutters
  - A. Composition and Inserts
  - B. Uses
  - C. Lead Angles and Rake Angles
  - D. Wiper Flats

MFG-F6-LE
Operate Horizontal Milling Machines
Attachment 2: MASTER Laboratory Exercise

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1. The instructor will demonstrate:
    a. How to use plain milling cutters;
    b. How to use side milling cutters;
    c. How to use face milling cutters;
    d. How to recognize and utilize various spindles, arbors, and adaptors; and,
    e. How to set up workpieces appropriately.

2. Students will:
    a. Use plain milling cutters;
    b. Use side milling cutters;
    c. Use face milling cutters;
    d. Recognize and utilize various spindles, arbors, and adaptors; and,
    e. Set up workpieces appropriately.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name____________________________ Date________________

MFG-F6
Operate Horizontal Milling Machines
Self-Assessment

Circle the letter preceding the correct answer.

1. What is one of the purposes of the overarm?
   A. To hold the quill
   B. To reduce vibration
   C. To perform regressing cuts
   D. All of the above answers are valid.
   E. None of the above answers are correct.

2. A bed-type milling machine has a fixed ___ and an adjustable ___.
   A. Bed. . .spindle
   B. Bed. . .quill
   C. Spindle. . .table
   D. Spindle. . .bed
   E. None of the above items is correct.

3. Horizontal milling machines have attachments that emulate the functions of:
   A. Vertical milling machines.
   B. Spiral mills.
   C. Angular swivels.
   D. All of the above answers are valid.
   E. None of the above answers is correct.

4. Which of the following is *not* a hazard of the horizontal milling machine?
   A. Loose hair being wrapped around a smooth, spinning shaft
   B. Jewelry causing electrical sparks or shorts
   C. Long sleeves getting caught in rotating machinery
   D. All of the above are hazards of the horizontal milling machine.
   E. None of the above answers is correct.

5. Technician A says that the horizontal milling machine has locks on the table, saddle, and knee. Technician B says that, while milling, all locks should be engaged except that of the moving axis. Who is correct?
   A. Technician A only
   B. Technician B only
   C. Both technicians are correct.
   D. Neither technician is correct.

6. The universal milling machine has a ___ and is specially adapted to cut ___.
   A. 45° table swivel. . .helical grooves
   B. 45° table swivel. . .circular runs
   C. 90° table swivel. . .helical grooves
   D. 90° table swivel. . .circular runs
   E. None of the above answers is correct.

7. Technician A says that the style A arbor is used only on small milling machines. Technician B says that the style B arbor is used to obtain a rigid setup for heavy-duty operations. Who is correct?
   A. Technician A only
   B. Technician B only
   C. Both technicians are correct.
   D. Neither technician is correct.

8. A stub arbor is:
   A. Also known as a shell end mill arbor.
   B. Sometimes called a style C arbor.
   C. Used to hold shell end milling cutters.
   D. All of the above answers are correct.
   E. None of the above answers is correct.

9. Technician A says that the direction of rotation of a milling cutter determines whether it is right- or left-handed. Technician B says that counter-clockwise rotation determines right-handed cutting. Who is correct?
   A. Technician A only
   B. Technician B only
   C. Both technicians are correct.
   D. Neither technician is correct.

10. If the workpiece is *narrower* than the cutter itself, the technician should use a:
   A. Shell end milling cutter.
   B. Side milling cutter.
   C. Plain arbor-driven cutter.
   D. Any of the above cutters are appropriate.
   E. None of the above answers is correct.

11. Steps and grooves are generally cut with a:
   A. Shell end milling cutter.
   B. Side milling cutter.
   C. Plain arbor-driven cutter.
   D. Any of the above cutters are appropriate.
   E. None of the above answers is correct.

12. What is the advantage of a staggered-tooth side milling cutter?
   A. Reduced chatter
   B. Better chip formation
   C. Higher feeds
   D. All of the above answers are correct.
   E. None of the above answers is correct.

13. Inserted-tooth carbide cutters usually have an adjustment width of:
   A. 0.060 inch.
   B. 0.060 centimeters.
   C. 0.060 millimeters.
   D. This is a trick question. Inserted-tooth carbide cutters are not adjustable.
   E. None of the above answers is correct.

14. When mounting the workpiece directly to the table, the clamp supports must be ___ the workpiece.
   A. Lower than
   B. The same height as
   C. Higher than
   D. It just doesn't matter.
   E. None of the above answers is correct.

15. Angular milling cutters are used for:
   A. V-notches.
   B. Dovetails.
   C. Serrations.
   D. All of the above are cut with angular milling cutters.
   E. None of the above answers is correct.

16. Very deep cuts are generally made with ___, due to their greater chip-carrying capacity.
   A. Side tooth metal slitting saws
   B. Staggered tooth metal slitting saws
   C. Half side milling cutters
   D. Inserted-tooth carbide cutters
   E. None of the above answers is correct.

17. How is a plain vise, bolted to the machine table, aligned?
   A. With two perpendicular slots on the underside of the vise
   B. With two parallel slots on the underside of the vise
   C. By the use of removable keys that fit into the table's T-slots
   D. By A combined with C
   E. By B combined with C

18. In normal toolroom work, a vise must be tightened by ___ whenever high stress is used in cutting.
A. Pneumatic attachments
B. Hydraulic attachments
C. Striking the crank handle of the vise with a soft-faced mallet
D. Striking the crank shaft of the vise with a ball-peen hammer
E. None of the above answers is correct.

19. A swivel vise can be rotated ___ degrees vertically and ___ horizontally.
A. 360 . . . 0
B. 270 . . . 90
C. 180 . . . 180
D. 90 . . . 270
E. 0 . . . 360

20. Generally speaking, a depth of cut of less than ___ will cause the cutter to *rub* rather than *cut*.
A. .030 inch
B. .015 inch
C. .005 inch
D. .001 inch
E. None of the above answers is correct.

21. Most milling with carbide cutters is done dry. Why?
A. An interrupted flow of cutting fluid will ruin the mill engine.
B. An interrupted flow of cutting fluid will cause thermal cracking of the tool.
C. Carbide cutters must be cooled strictly in air to maintain their cutting edges.
D. The premise of this questions is flawed. Carbide cutters use cutting fluid just like other cutters.
E. None of the above answers is correct.

22. Under normal conditions, when should the machinist choose climb milling for the horizontal milling machine?
A. When the workpiece must be cut to extremely tight tolerance
B. When the cutter is beginning to dull
C. When the tolerance of the workpiece is very loose
D. Climb milling is not recommended under most conditions.
E. None of the above answers is correct.

23. When gang milling, the cutter rpm is determined by the diameter of the ___ cutter in the gang.
A. Largest
B. Average
C. Smallest
D. Gang milling can only be done with cutters of equal diameters.
E. None of the above answers is correct.

24. High-speed face milling cutters are normally used with ___ rake angles.
A. Positive
B. Neutral or no
C. Negative
D. Large, regardless of the declinsion.
E. None of the above answers is correct.

25. When finishing, the machinist should use ___ wiper flat(s) with a maximum feed rate of ___ of the width of one wiper flat.
A. One . . . one-half
B. One . . . two-thirds
C. Two . . . one-half
D. Two . . . two-thirds
E. None of the above answers is correct.

MFG-F6
Operate Horizontal Milling Machines
Self-Assessment Answer Key

1.	B
2.	C
3.	D
4.	D
5.	C
6.	A
7.	C
8.	D
9.	A
10.	C
11.	B
12.	D
13.	A
14.	B
15.	D
16.	B
17.	D
18.	E
19.	E
20.	C
21.	B
22.	D
23.	A
24.	A
25.	B

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-F7

Subject: **Manufacturing Technology** **Time: 40 Hrs.**

Duty: **Perform Conventional Machining**
Task: Operate Metal Cutting Lathes

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify major component parts of an engine lathe;
b. Properly set up and use lathe accessories required for basic lathe operation;
c. Determine correct speed and feed for a given metal;
d. Identify safety concerns relative to lathe operation;
e. Demonstrate set up and use of lathe centers;
f. Identify and use different types of lathe cutting tools;
g. Face, cut and turn stock to a specified tolerance;
h. Demonstrate method of drilling, boring and reaming a hole to obtain specified tolerance; and,
i Demonstrate setup and correct procedures to machine sixty-degree internal and external threads.

Instructional Materials:

MASTER Handout (MFG-F7-HO)
MASTER Laboratory Exercise (MFG-F7-LE)
MASTER Laboratory Aid (MFG-F7-LA)
MASTER Self-Assessment
2" aluminum stock for practice and evaluation
9 5/8" of 1" diameter CRS
Assortment of outside micrometers up to 3"
Depth gage
Dial calipers
Engine lathe
Hand tools
Side shield and face shield
Telescope gage
Tool grinder
Tool stock

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition, “Turning Machines”

NTMA Modules:

MA-I-26	“Engine Lathe: Introduction”
MA-I-28	“. . .Care & Safety”
MA-I-30	“. . .Type & Function”
MA-I-32	“. . .Cutting Tools & Fluids”
MA-I-34	“. . .Accessories & Work Holding Devices
MA-I-36	“. . .Selecting Speeds & Feeds”
MA-I-38	“. . .Facing, Turning & Boring
MA-I-40	“. . .Drilling, Reaming & Taper Turning
MA-I-42	“. . .Threading”
MA-I-44	“. . .Auxiliary Tooling”

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1 through MFG-A7 “Practice Safety”
MFG-B7 “Calculate Speeds and Feeds for Machining”
MFG-C1 through MFG-C10 “Interpret Engineering Drawings and Control Documents”
MFG-E3 “Measure With Hand Held Instruments”
MFG-F1 “Prepare and Plan for Machining Operations”

Introduction:

The lathe is the single most important tool of the machinist. Of all the machines we make and use, only the lathe is capable of being used to replicate itself. While this aspect alone makes it unique in industry, the lathe is most extensively used to fabricate and duplicate cylindrical parts for other machines. Expertise in the lathe is *the* fundamental skill of a machinist.

Presentation Outline:

I. Discuss the Importance of the Lathe to the Machinist. Provide Classroom Handouts and Laboratory Worksheets to the Students.
II. Identify and Discuss Component Parts of the Engine Lathe
III. Discuss Lathe Safety
IV. Identify, Set Up, and Demonstrate Use of Lathe Accessories
    A. Cutting Fluids
    B. Follower and Steady Rest
    C. Compound Rest

    - D. Mandrel
- V. Discuss and Demonstrate How to Select the Correct Speed and Feed for Various Metals
    - A. Steel
    - B. Aluminum
    - C. Brass
- VI. Discuss and Demonstrate the Use of Lathe Centers
    - A. Mounting
    - B. Removing
    - C. Aligning
- VII. Discuss and Demonstrate Use of Cutting Tools
    - A. Grinding a high speed toolbit
    - B. Re-conditioning point of toolbits
    - C. Types of cutting tools
- VIII. Discuss and Demonstrate Turning Between Centers
    - A. Why face out?
    - B. Center drill
    - C. Tailstock center
    - D. The steady rest
    - E. Using chucks
- IX. Discuss and Demonstrate Methods of Drilling, Boring, and Reaming Using the Lathe
- X. Discuss Threads, Threading, and Thread Applications
- XI. Student Practice

Practical Application:

Students will make a light-weight ball-peen hammer and a gravity-feed center punch in the laboratory. These projects also constitute their performance demonstrations.

Evaluation and/or Verification:

Successful completion of this Technical Module will be based on the student's successful completion of the following components. The student shall:

1. Complete the Self-Assessment at the end of this module.
2. Successfully identify the parts of the lathe. The instructor will determine whether the student is ready to progress.
3. Demonstrate safe operation of the lathe.
4. Fabricate the hammer to the specified tolerances when given the drawing, detailed instructions, tools, equipment, and work stock.
5. Fabricate the punch to the specified tolerances when given the drawing, tools, equipment, and work stock.

Summary:

Review the main lesson points using the objectives as a guide. Hold class discussions and answer students' questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-F8) dealing with operating grinding/abrading machines.

MFG-F7-HO
Operate Metal Cutting Lathes
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Identify major component parts of an engine lathe;
- b. Properly set up and use lathe accessories required for basic lathe operation;
- c. Determine correct speed and feed for a given metal;
- d. Identify safety concerns relative to lathe operation;
- e. Demonstrate set up and use of lathe centers;
- f. Identify and use different types of lathe cutting tools;
- g. Face, cut and turn stock to a specified tolerance;
- h. Demonstrate method of drilling, boring and reaming a hole to obtain specified tolerance; and,
- i Demonstrate setup and correct procedures to machine sixty-degree internal and external threads.

Module Outline:

- I. Discuss the Importance of the Lathe to the Machinist. Provide Classroom Handouts and Laboratory Worksheets to the Students.
- II. Identify and Discuss Component Parts of the Engine Lathe
- III. Discuss Lathe Safety
- IV. Identify, Set Up, and Demonstrate Use of Lathe Accessories
  - A. Cutting Fluids
  - B. Follower and Steady Rest
  - C. Compound Rest
  - D. Mandrel
- V. Discuss and Demonstrate How to Select the Correct Speed and Feed for Various Metals
  - A. Steel
  - B. Aluminum
  - C. Brass
- VI. Discuss and Demonstrate the Use of Lathe Centers
  - A. Mounting
  - B. Removing
  - C. Aligning
- VII. Discuss and Demonstrate Use of Cutting Tools
  - A. Grinding a high speed toolbit
  - B. Re-conditioning point of toolbits
  - C. Types of cutting tools

VIII. Discuss and Demonstrate Turning Between Centers
    A. Why face out?
    B. Center drill
    C. Tailstock center
    D. The steady rest
    E. Using chucks
IX. Discuss and Demonstrate Methods of Drilling, Boring, and Reaming Using the Lathe
X. Discuss Threads, Threading, and Thread Applications
XI. Student Practice

MFG-F7-LE
Operate Metal Cutting Lathes
Attachment 2: **MASTER** Laboratory Exercise

I. The instructor will discuss and review the working drawings.

II. Students will practice safe work habits at all times.

III. Students will review the work prints at their work stations. (Be sure you understand *all aspects* of the working drawings before beginning the exercise.)

IV. Specific Procedures for This Exercise
A. General Shop Rules
1. Immediately put absorbent on all oil spills.
2. Thoroughly clean the machine and the area around it when you are finished working at that station.
3. Return all assigned tools to their proper places.
B. General Lathe Rules
1. Never attempt to stop a turning chuck.
2. Never try to measure moving parts. Wait until they stop.
3. The chuck should always turn *toward* you when it is in the FORWARD position.
4. The tool steel should not stick out more than one-half inch from the toolholder.

V. Fabrication of the Ball-Peen Hammer—Handle Form
A. Cut off at least 9 5/8 inches of 1 inch diameter CRS (cutting speed 100); wipe it clean and deburr it on the pedestal grinder using the coarse wheel.
B. Check the following before starting the lathe.
1. The spindle should be free.
2. The carriage should be free.
3. The cross feed should be free.
4. The chuck wrench **must** be removed from the chuck.
C. Face the stock to a length of 9 ½ inches.
D. Center drill each end.
E. Put the chuck on 2 inches of the stock and support the workpiece with the tailstock and the live center.
F. Mark 6 inches from the end of the workpiece with the turning tool.
G. Turn this 6 inches down to 0.800 inch.
1. Touch the rotating workpiece with the tool and set the crossfeed dial to zero (0).

    2. Take four cuts of 0.050 at a feed of 0.004.
    3. On the fourth cut, stop the feed after 3/8 inch and check for the proper diameter. Adjust as necessary.
  H. Mark 5/8 inch from the end of the workpiece.
  I. Turn this 5/8 inch down to 0.550.
  J. File all edges using the file handle in the left hand.
  K. File a straight flat along the turned surface in line with the #1 chuck jaw.
  L. Unchuck the workpiece. *Remove the chuck wrench.*
  M. Remove the workpiece and place 2 inches of the turned end into the chuck, placing the file flat under the #1 chuck jaw. *Remove the chuck wrench.*
  N. Adjust the tailstock pressure so that the live center turns with the workpiece.
  O. Mark 4 5/8 inches from the end and turn to 0.700 OD ± 0.005.
  P. Mark 4 3/16 inches from the end and turn to 0.600 OD ± 0.005.
  Q. Mark 3 3/8 inches from the end and turn to 0.425 OD ± 0.005.
  R. Set the lathe to the proper feed and speed for finishing and finish the three ODs from O, P, & Q to the print dimensions.
  S. Break all sharp edges with a file.
  T. Reverse the work. Chuck on the 0.375 OD. *Remove the chuck wrench.* Protect the finished ODs with an appropriate buffer.
  U. Finish turning the handle to the print dimensions.

VI. Fabrication of the Ball-Peen Hammer—Threads and the Head
  A. Cut off at least 4 1/8 inches of 1 inch diameter 4140, painted red (cutting speed 60). Clean and deburr as before.
  B. Face one end.
  C. Mark 5/8 inch from the end and turn to 0.500 + 0.000 -0.010.
  D. File a flat for the #1 chuck jaw, reverse the work and repeat B and C for the other end of the workpiece.
  E. Get the parting tool for the respective machine.
    1. Check the parting tool for sharpness.
    2. Mount the parting tool in the tool post.
    3. Make sure that the parting tool is square to the workpiece and on center.
    4. Feed slowly, using both hands, at 100 RPM.
  F. Cut a neck for the threads to run on at each end of the head and on one end of the handle.
    1. Touch the parting tool to the workpiece and zero the cross slide.
    2. Feed in the double depth of the thread plus 0.010.
  G. Thread both ends of the head to ½-20-NF. Test the threads with a test nut. *Do not proceed to H without instructor approval.*
  H. Thread one end of the handle to ½-20-NF.

I. Either of two common methods of threading may be used. Check with the instructor before proceeding.
1. Die and Pad
a. Fix the handle on the large end.
b. Using the die and the flat crotch pad, thread the small end of the handle to 3/8-24-NF.
2. Threading Tool—thread to 3/8-24-NF.
J. Chuck onto the practice threads of the head and support the workpiece with the tailstock and live center.
K. Center drill the end of the head.
L. Mark 1 7/8 inches from the shoulder and turn to 0.875 ± 0.003. Make sure that the top tolerance is used to allow for filing and polishing.
M. Mark the #1 jaw, reverse the workpiece and center drill the other end.
N. From the 0.875 OD, turn the workpiece down to 0.750 ± 0.003.
O. Using the threading tool, mark the workpiece
1. 13/16 inch *in from* the 0.875 OD.
2. 3/8 inch in from the first mark.
3. 5/8 inch in from the second mark.
4. 3/8 inch in from the third mark.
P. Under cut the 3/8 inch spaces to 9/16 inch OD ± 1/64. Use a round nose tool, set the RPM to 100, and feed by hand. Make the last cut slowly to leave the cut smooth.
Q. Turn off the practice threads. Protect the finish in the chuck with an appropriate buffer.
R. Crown face the head end and free-hand form the ball peen.
S. Check all dimensions against the drawing for accuracy.

VII. Fabrication of the Ball-Peen Hammer — Knurling
A. Chuck the handle at the 0.550 diameter (with proper buffers) and support the 0.500 diameter end with a well-lubricated dead center.
B. Carefully mark where the knurl will be made.
C. Set a medium knurling tool square to the workpiece and on center.
D. Set the lathe to the proper feed and speed.
E. Knurl the handle, using plenty of lubricants. Be sure that the pattern is correct *before* knurling the whole handle.
F. Knurl the 1/4 inch cap screw. If a correct pattern is not obtained, knurl the entire handle grip and turn off the poorly-executed end.

VIII. Fabrication of the Ball-Peen Hammer — Completing the Handle
A. Chuck on the knurl (buffer correctly).
B. *While maintaining the tolerances,* file and polish each diameter of the handle separately.
C. Clean the lathe especially well after polishing.

D. Move to the work bench. Place the handle in a vise (buffer the knurl) and saw off the end for the screw with a hacksaw.

E. Face the handle to length and drill and tap the storage hole as required.

F. Clean out the hole and install the screw. (A paper gasket may help prevent over-tightening.)

G. Face the screw to length and break the sharp edge. The handle is now complete.

IX. Fabrication of the Ball-Peen Hammer — Completing the Head

A. Lay out, center punch, and drill the head to the proper depth. Use the drill jig designed for this operation.

B. Tap the bore using a plug and bottom tap. Be sure the taps are started straight.

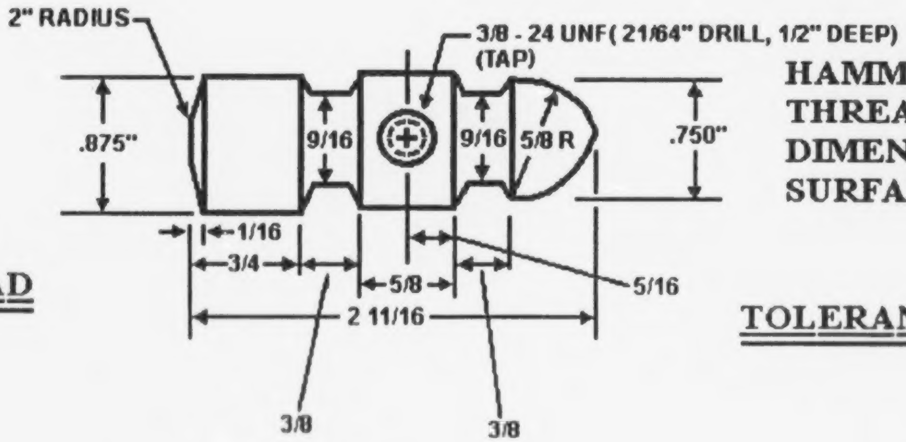
C. Polish the hammer head and clean the work area.

D. Heat the face of the hammer and the ball peen to cherry red; quench them in oil. Re-polish the head.

E. Heat the face of the hammer and the ball peen to straw color; quench them in oil. Re-polish the head.

X. Turn in the hammer and blueprints to the instructor for evaluation. You will know how well you have done by whether the hammer parts all actually fit together well and whether they are within tolerances.

XI. Once you have obtained the instructor's approval, you are ready to begin construction of the gravity-fed center punch. For that exercise, you will not be given linear instructions. You must use your own judgement on how and when to do what, following the blueprints. Remember to stay within tolerances, to keep your work area clean, and keep your chuck key in your hand or in your tool kit *at all times and in all circumstances*. Good Luck!


2" RADIUS
3/8 - 24 UNF (21/64" DRILL, 1/2" DEEP)
(TAP)
.875"
9/16
9/16
5/8 R
.750"
1/16
3/4
5/8
5/16
2 11/16
3/8
3/8

HEAD

HAMMER GRADE: ____________

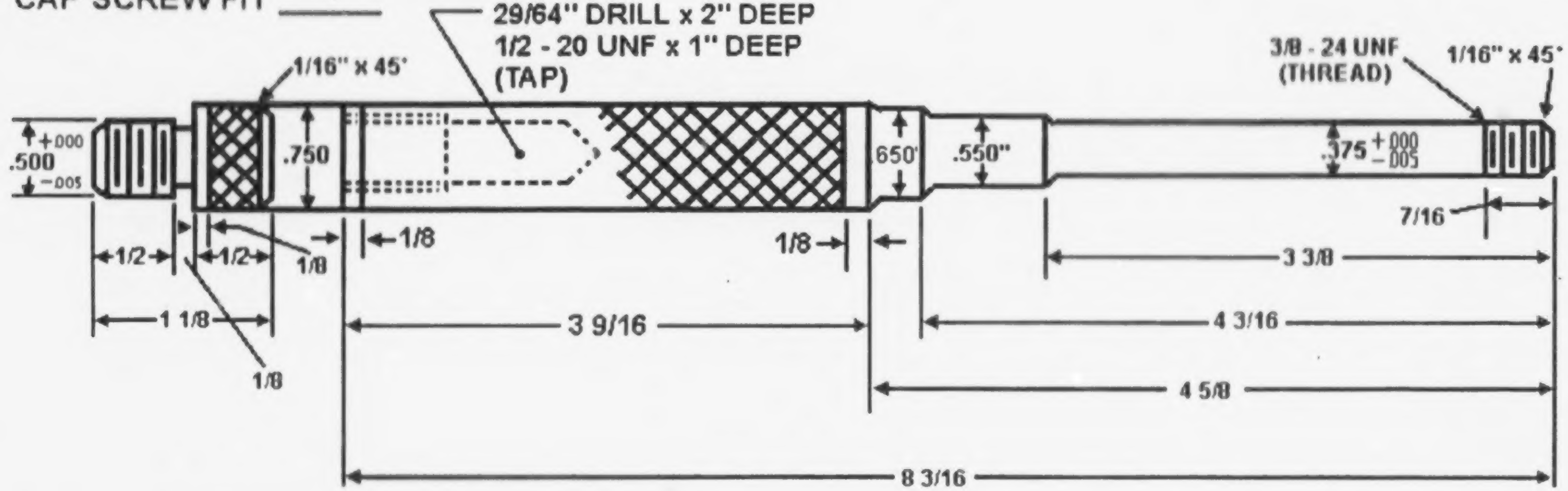
THREAD SQUARENESS: ____________

DIMENSIONS MISSED: ____________

SURFACE FINISH: ____________

TOLERANCES: FRACTIONS ± 1/64"
DECIMALS ± .005"

CAP SCREW FIT ______

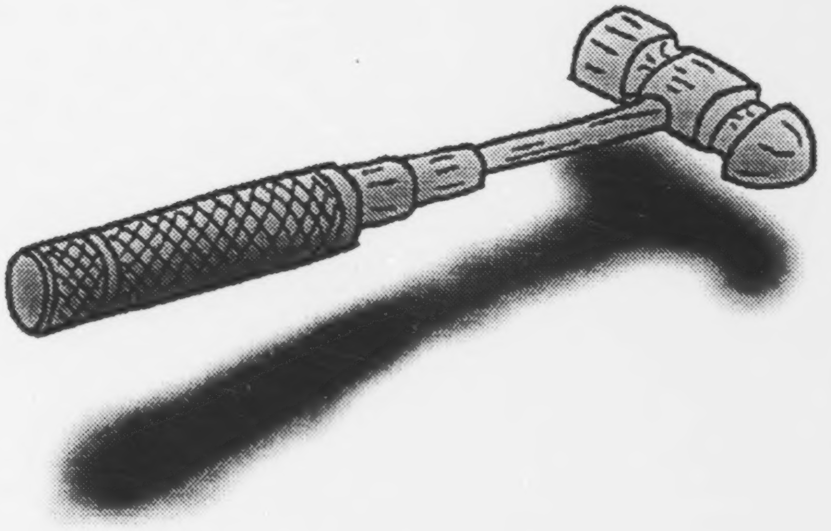

29/64" DRILL x 2" DEEP
1/2 - 20 UNF x 1" DEEP
(TAP)
1/16" x 45°
3/8 - 24 UNF
(THREAD)
1/16" x 45°
+.000
.500
-.005
.750
.650"
.550"
.375 +.000 -.005
1/2
1/2
1/8
1/8
1/8
1/8
1/8
7/16
3 3/8
1 1/8
3 9/16
4 3/16
4 5/8
8 3/16

MATERIAL

HEAD 4140 - HANDLE - C.R.S. 12 L 14

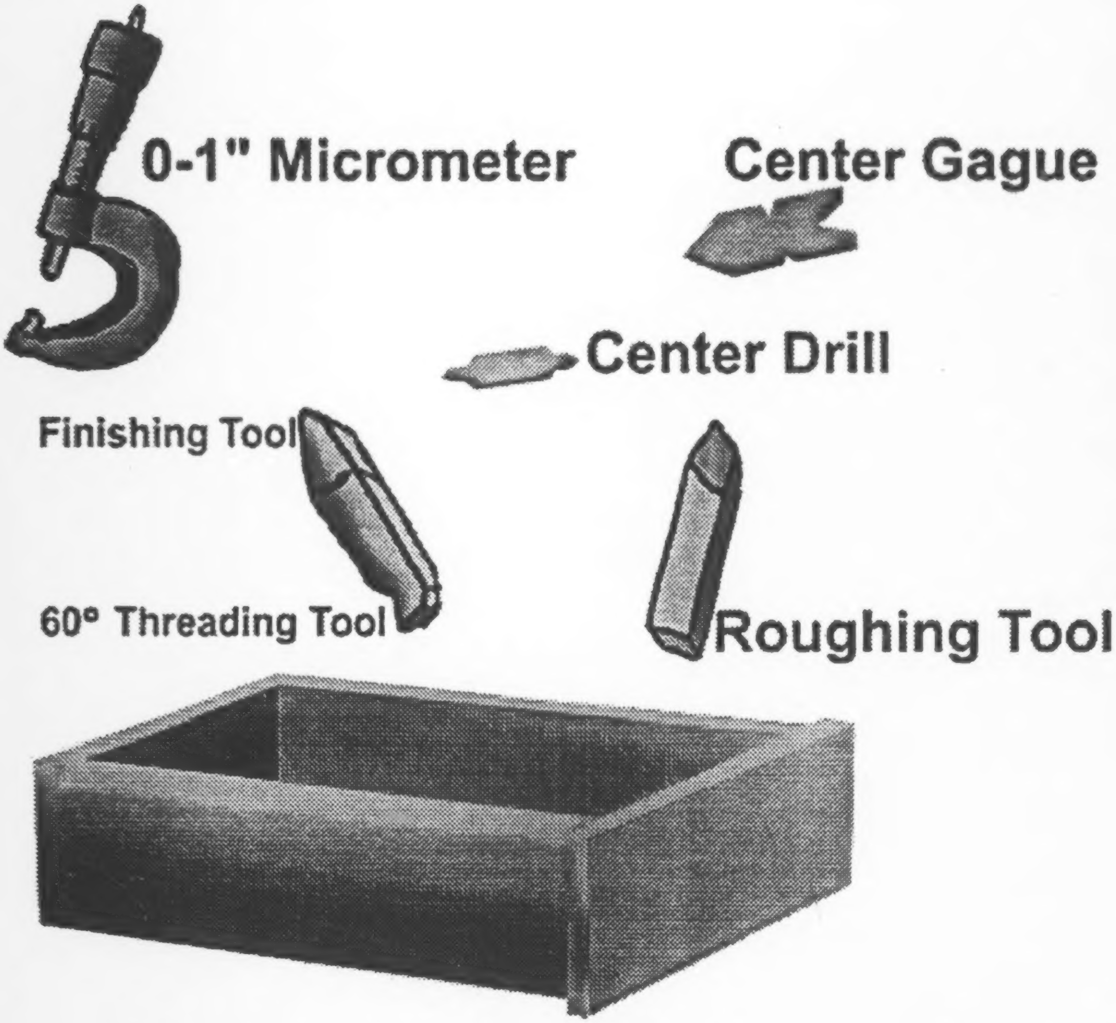
HANDLE

BALL PEEN HAMMER



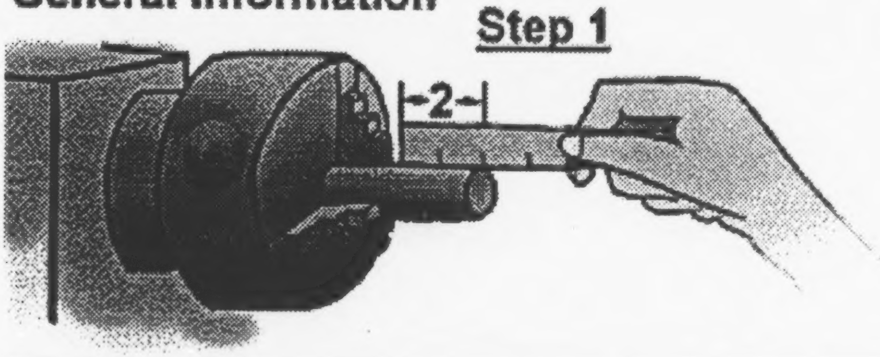
Objectives:

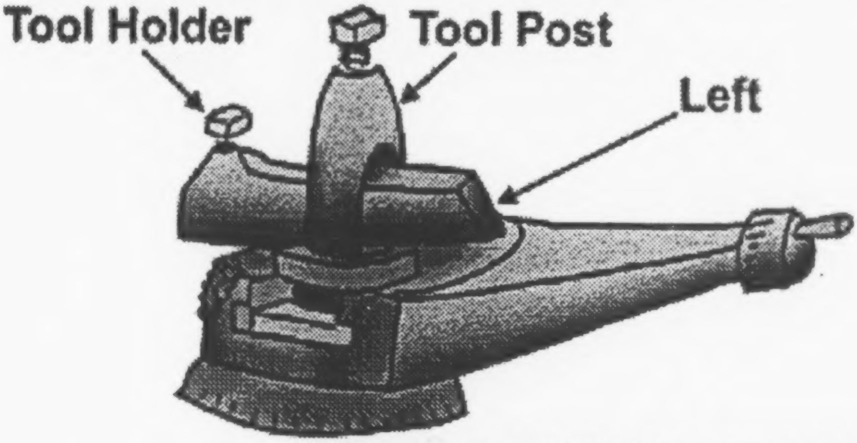
1. Become accquainted with work done in a machine shop.
2. Practice Engine Lathe Operation.
3. Observe the need for careful measuring.
4. See first hand the need for shop safety.


0-1" Micrometer
Center Gague
Center Drill
Finishing Tool
60° Threading Tool
Roughing Tool

These tools should be in your box.

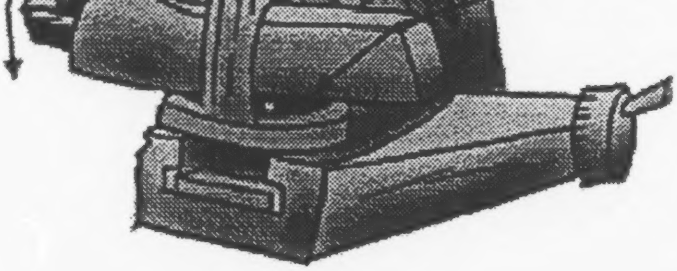
General Information

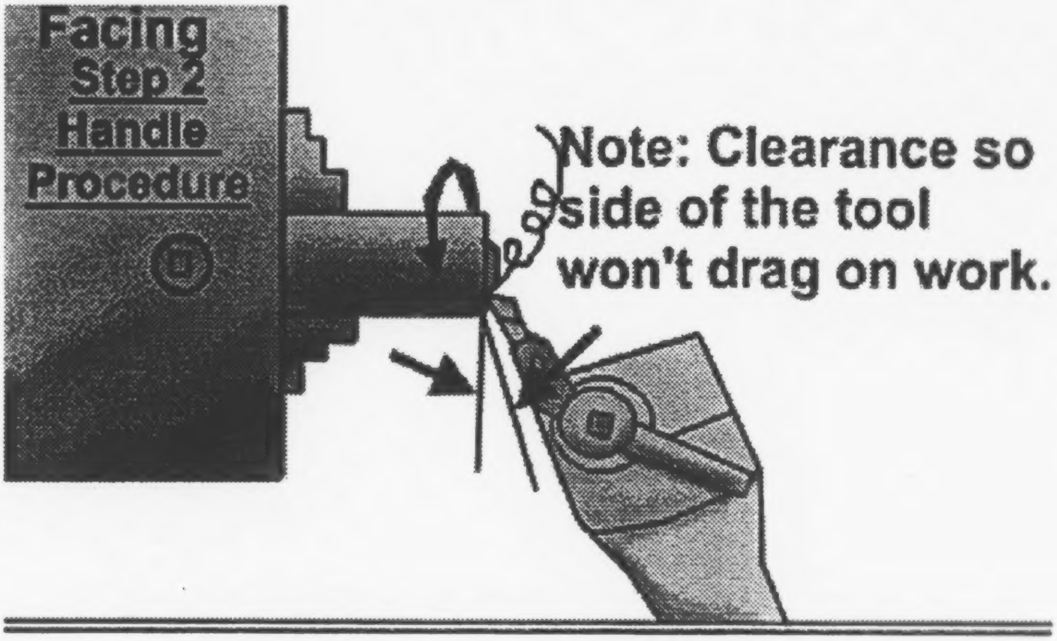


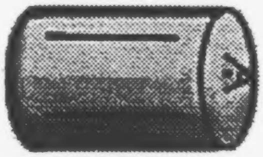

Tool Holder
Tool Post
Left

Mount Tool Holder to extreme left.

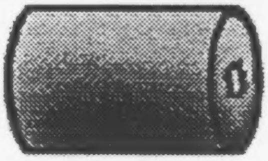
Setting cutting tool height
Using the tailstock center
as a guide.



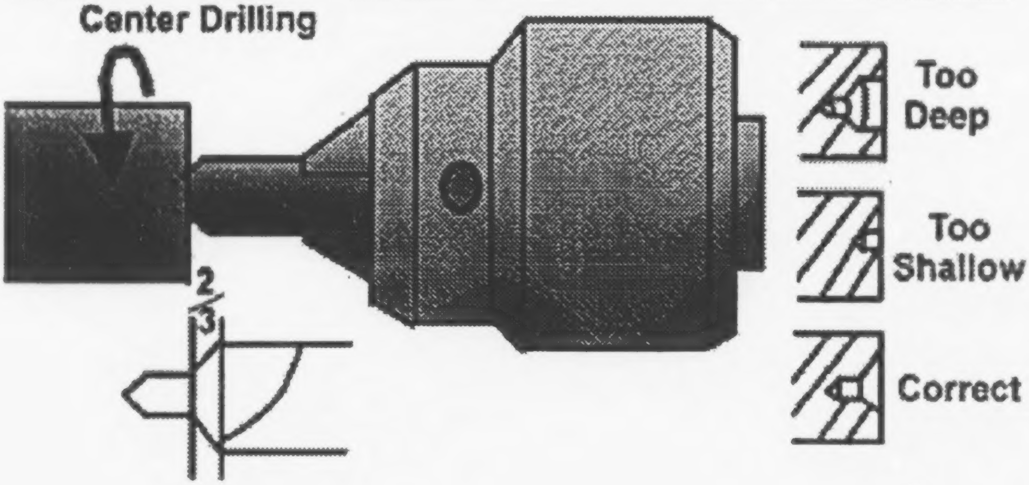

Facing
Step 2
Handle
Procedure
Note: Clearance so side of the tool won't drag on work.



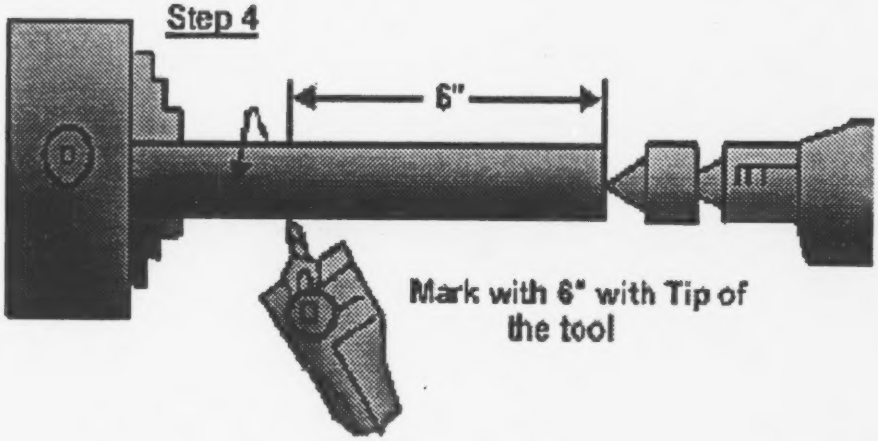
Point, Tool too Low.



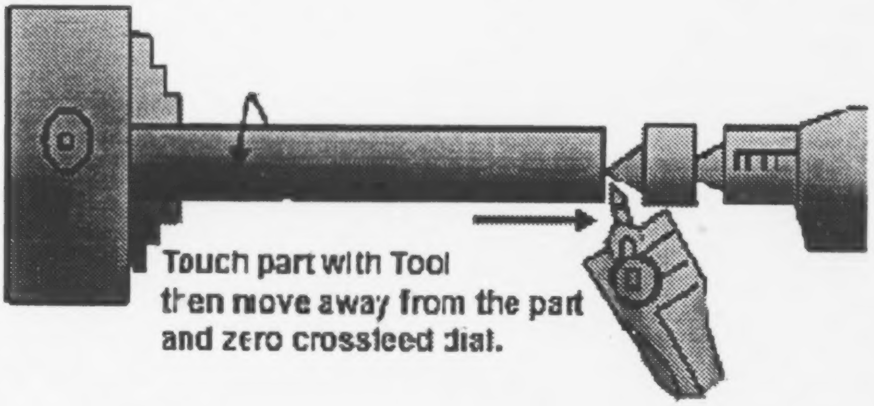
Rough, Tool too High.


Center Drilling
2/3
Too Deep
Too Shallow
Correct

Step 4

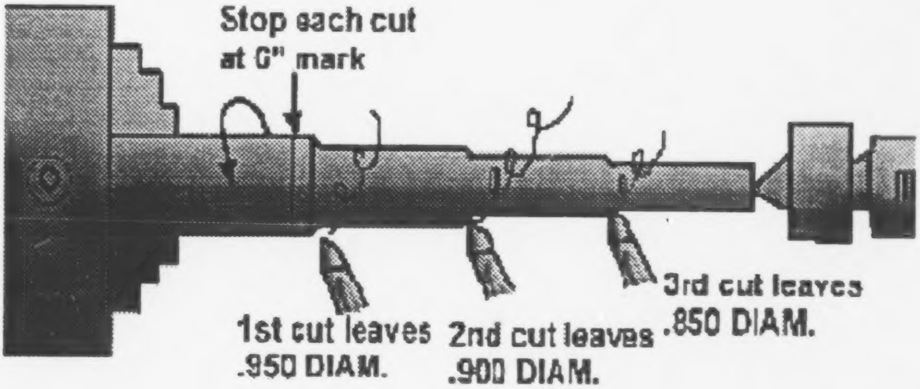


Mark with 6" with Tip of the tool



Touch part with Tool then move away from the part and zero crossfeed dial.

STEP 5



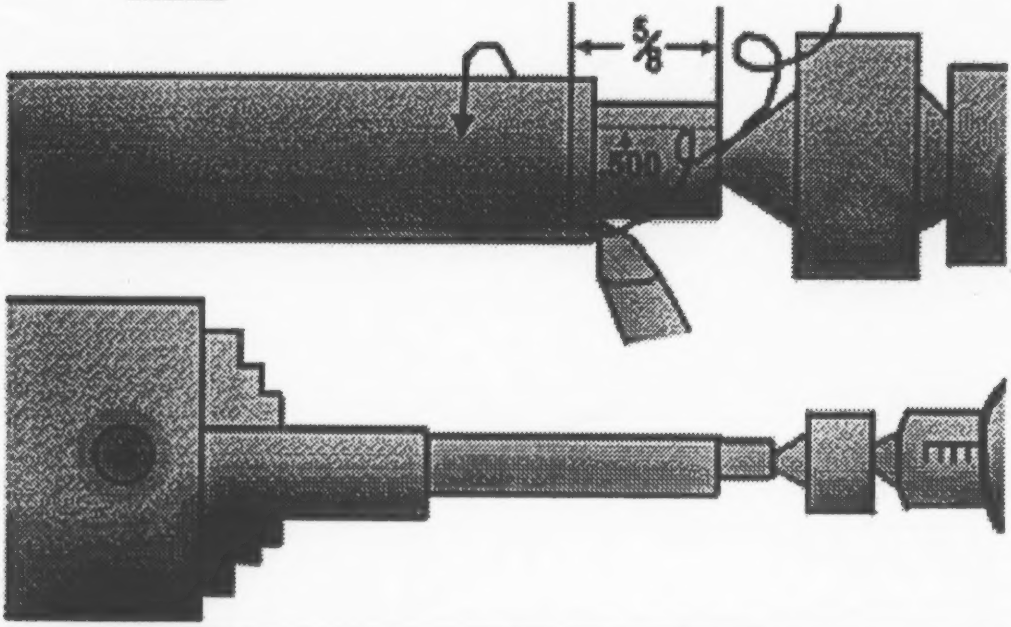
Stop each cut at 6" mark

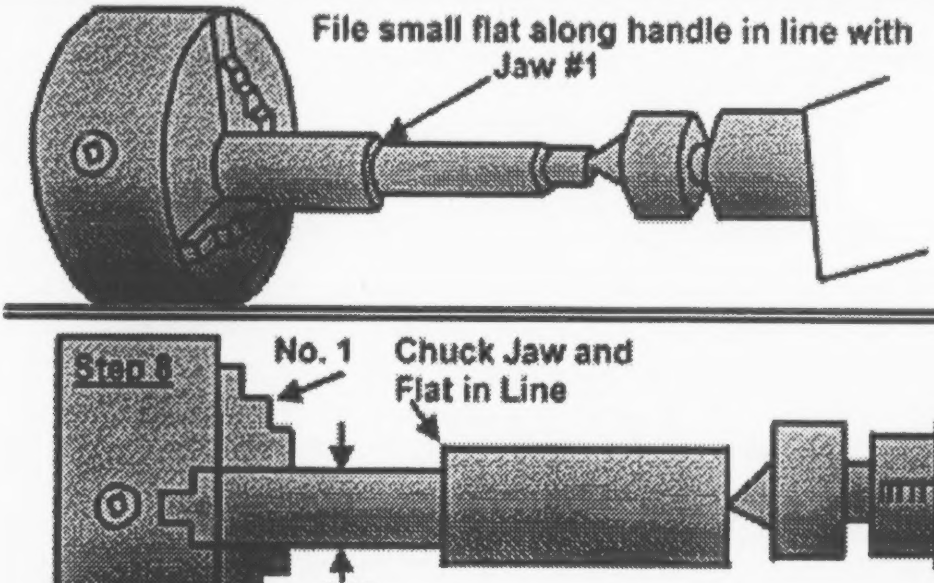
1st cut leaves .950 DIAM.

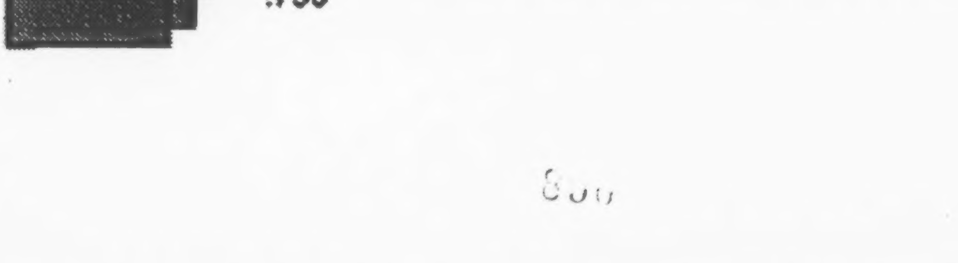
2nd cut leaves .900 DIAM.

3rd cut leaves .850 DIAM.

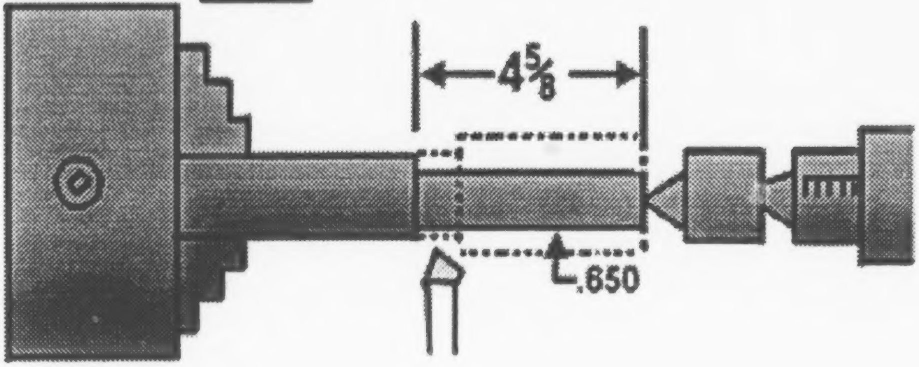
Step 6



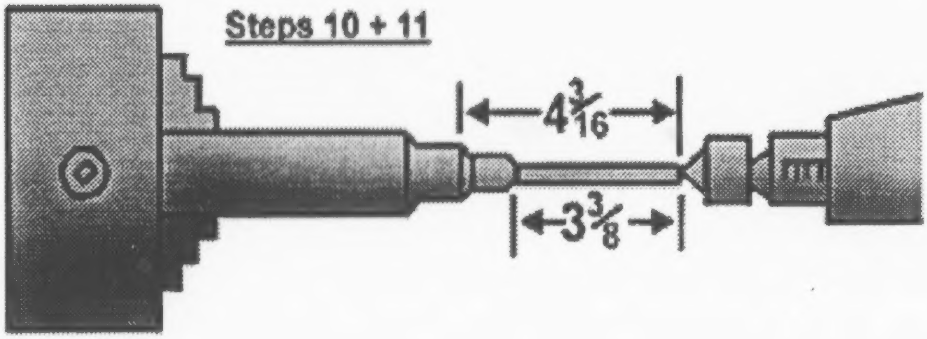

File small flat along handle in line with Jaw #1

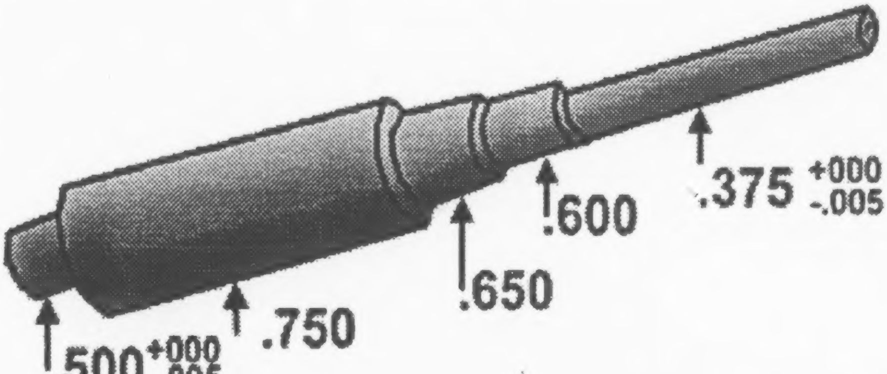

Step 8
No. 1
Chuck Jaw and Flat in Line
.750

STEP 9

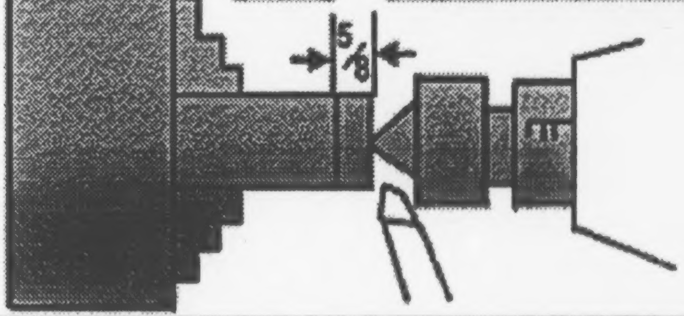


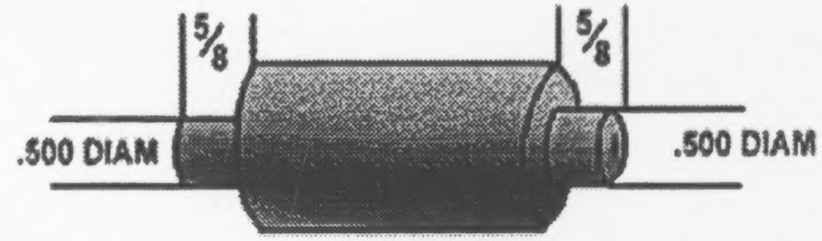
Steps 10 + 11

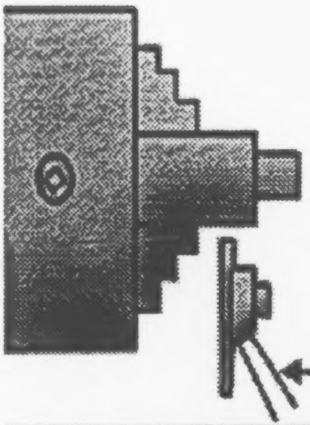


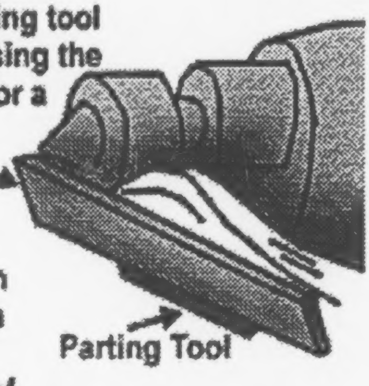

.375 +000 -.005
.600
.650
.750
.500 +000 -.005

STEP 3 HAMMER HEAD PROCEDURE

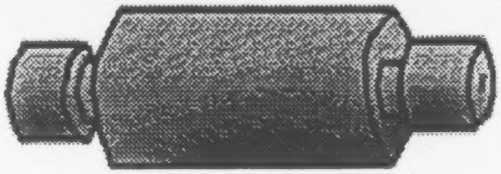



5/8
5/8
.500 DIAM
.500 DIAM

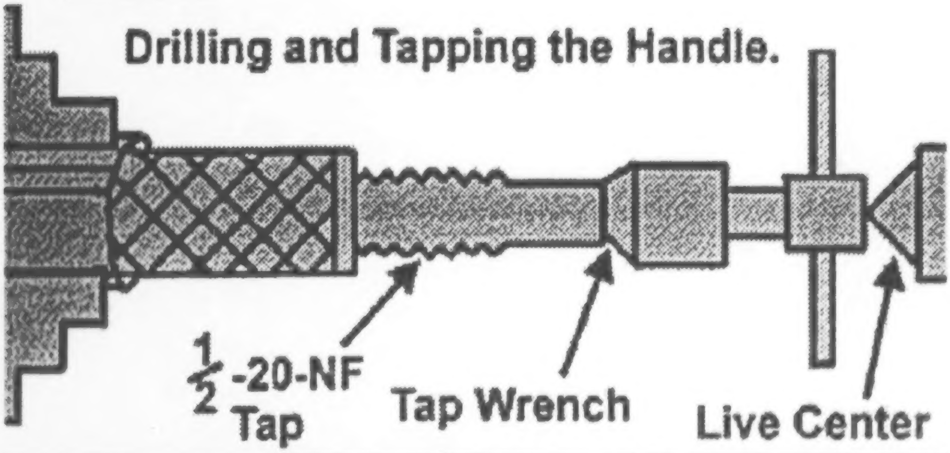

Measure from face of chuch to check squareness of parting tool.


Setting parting tool on center using the live center for a gague.

Parting Tool



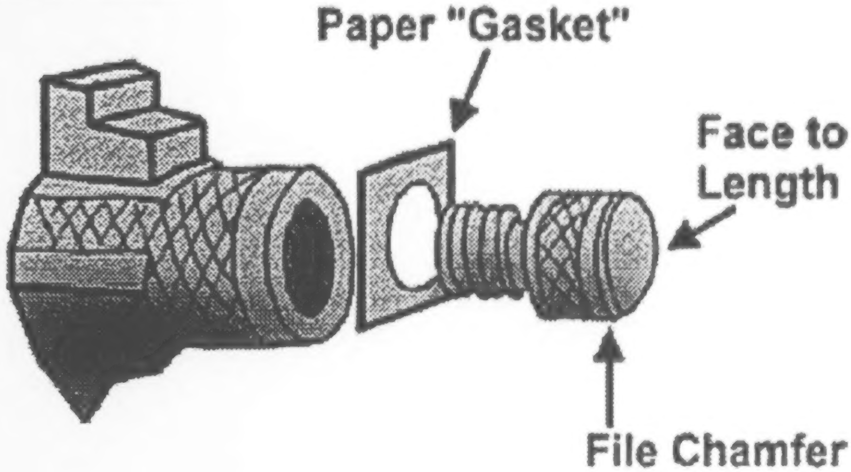
STEP 4



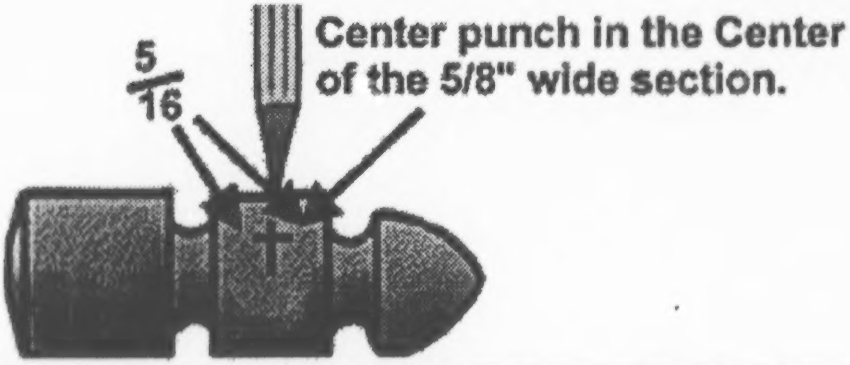
Drilling and Tapping the Handle.

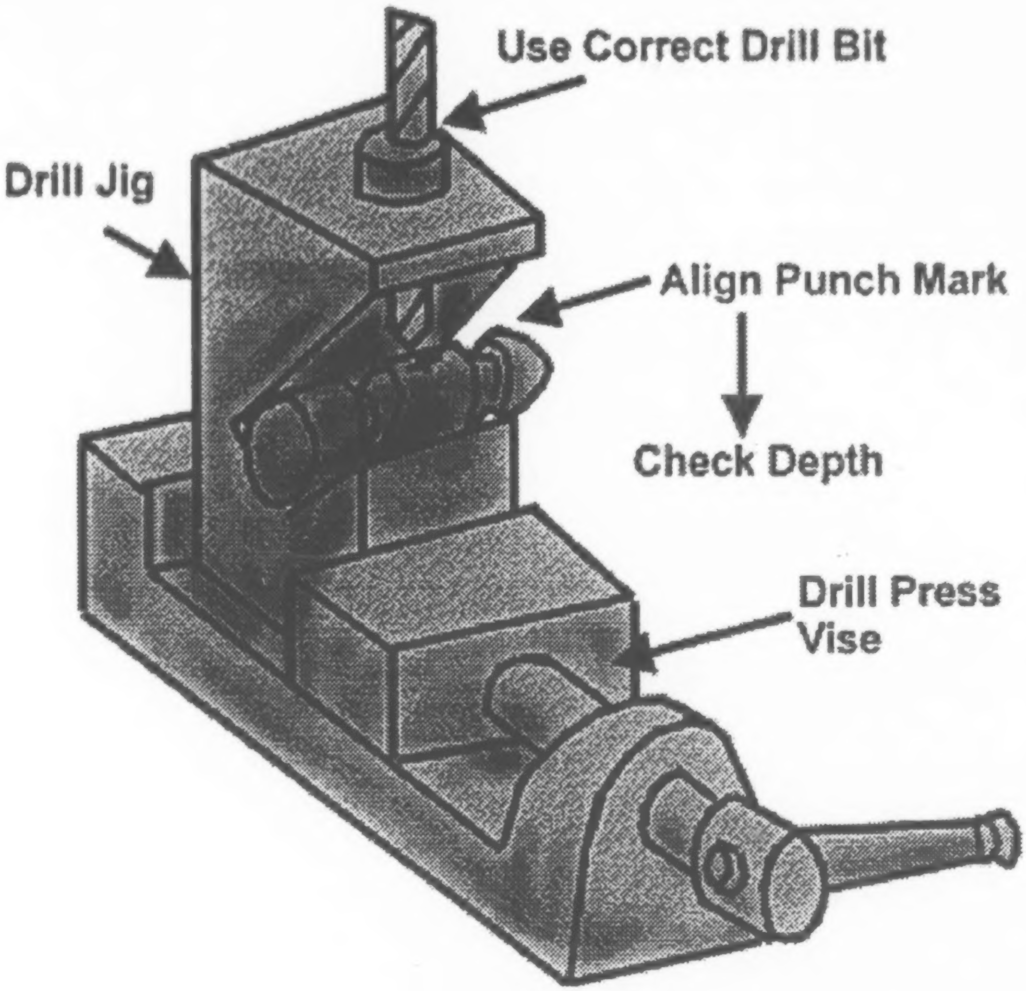
$\frac{1}{2}$-20-NF Tap
Tap Wrench
Live Center

STEPS 5+6



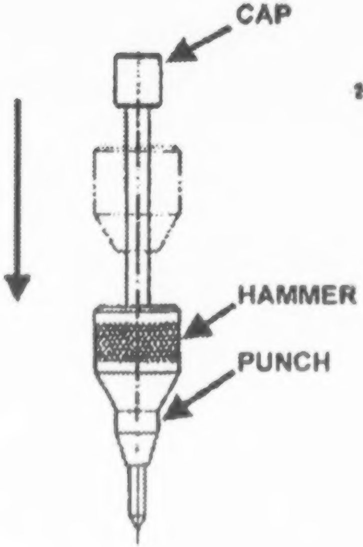
Paper "Gasket"
Face to Length
File Chamfer

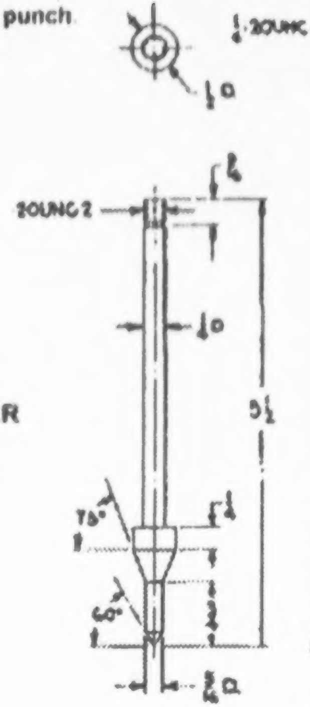

Center punch in the Center of the 5/8" wide section.
5/16


Use Correct Drill Bit
Drill Jig
Align Punch Mark
Check Depth
Drill Press Vise

GRAVITY CENTER PUNCH

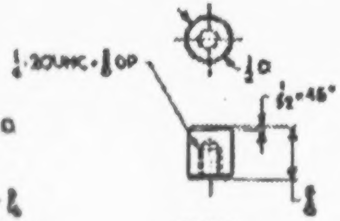
1. Material: As noted.
2. Finish: Accepted machine shop practice little or no filling.
3. Tolerances: As indicated by your instructor.
4. Break all sharp edges.
5. Heat Treat only the point section of the punch.


CAP
HAMMER
PUNCH


20UNC 2
5½
75°
60°

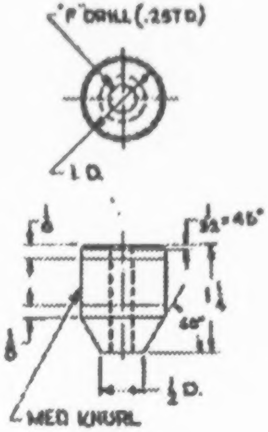
PUNCH

DRILL ROD - HEAT TREAT



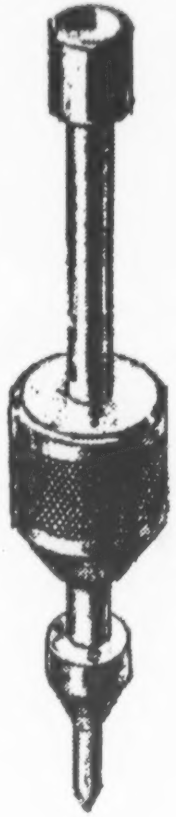
CAP

BRASS


"F" DRILL (.257 D)
1 D.
45°
60°
MED KNURL

HAMMER

C.R.S.



Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name______________________________ Date________________

MFG-F7
Operate Metal Cutting Lathes
Self-Assessment

Circle the letter preceding the most correct answer.

1. Machinist A says that technicians should keep their hands on their chuck wrenches "from the bench back to the bench." Machinist B says that the lathe is capable of turning thousands of times per minute. Who is correct?
   A. Machinist A only
   B. Machinist B only
   C. Both technicians are correct.
   D. Neither technician is correct.

2. Before starting the lathe, the machinist should ensure that the ___ is free (not locked).
   A. Spindle
   B. Carriage
   C. Crossfeed
   D. All of the above should be free before starting the lathe.
   E. None of the above answers is correct.

3. The chuck is driven by the:
   A. Spindle foot.
   B. Spindle nose.
   C. Saddle.
   D. Carriage.
   E. None of the above answers is correct.

4. Machinist A says that the half-nut (split-nut) lever should only be used to cut left-handed threads. Machinist B says that the half-nut lever is never used for general feeds. Who is correct?
   A. Machinist A only
   B. Machinist B only
   C. Both technicians are correct.
   D. Neither technician is correct.

5. Machinist A says that off-set toolholders are used for general machining on lathes. Machinist B says that straight-shank toolholders are used for machining close to the chuck or the tailstock to avoid interference from the tool post. Who is correct?
   A. Machinist A only
   B. Machinist B only
   C. Both technicians are correct.
   D. Neither technician is correct.

6. What is SCEA and why is it important?
   A. SCEA is the Side Cutting Edge Angle. If the SCEA is too large for the application, the tool may chatter.
   B. SCEA is the Side Cutting Edge Angle. If the SCEA is too large for the application, the tool will not cut.
   C. SCEA is the Spin-Chatter Elimination Attachment. If the SCEA is not attached, the lathe will not rotate uniformly and will chatter.
   D. SCEA is the Spinning Cleaning Enhancement Attachment. The SCEA makes the spindle, the toolholders, and the operator self-cleaning.
   E. None of the above answers is correct.

7. The ___ directs the chip flow toward the operator.
   A. Back rake
   B. Side rake
   C. Side relief angle
   D. No part of the lathe is designed to direct chip flow *toward* the operator.
   E. None of the above answers is correct.

8. Machinist A says that form tools have a tendency to chatter at higher speeds, so that cutting fluids and lower speeds are usually required. Machinist B says that form tools have special cutting faces that are used for external radii, threads, and dozens of other applications. Who is correct?
   A. Machinist A only
   B. Machinist B only
   C. Both technicians are correct.
   D. Neither technician is correct.

9. Cutoff or parting tools require a larger back rake for:
   - A. Tool steel.
   - B. Hard, non-ferrous metals.
   - C. Soft metals, such as aluminum.
   - D. The question is trivial; all cutoff tools have huge back rakes.
   - E. None of the above answers is correct.

10. What is the best solution to a tool which has been sharpened too many times?
   - A. Throw it away and replace it.
   - B. Lengthen the flank.
   - C. Grind off the old end and reform the cutting end.
   - D. Any of the above answers may be the solution.
   - E. None of the above answers is correct.

11. Which shape of chip is considered the safest?
   - A. C
   - B. 9
   - C. 8
   - D. D
   - E. None of the above answers is correct.

12. The back rake of high-speed steel tools is generally greater for ___ and virtually zero for ___.
   - A. Copper. . .alloy steels
   - B. Aluminum. . .bronze
   - C. Brass. . .nickel
   - D. Cast iron. . .brass (free cutting)
   - E. None of the above answers is correct.

13. When removing a chuck, the technician should *not* use a:
   - A. Monkey wrench.
   - B. Long steel bar.
   - C. Knockout bar.
   - D. All of the above may be used to remove the chuck.
   - E. None of the above answers is correct.

14. Machinist A says that the collet should never be tightened without a workpiece in its jaws. Machinist B says that it is important to clean the collets and adapters to ensure accuracy. Who is correct?
   A. Machinist A only
   B. Machinist B only
   C. Both technicians are correct.
   D. Neither technician is correct.

15. To ensure accuracy, the workpiece should not vary in size from the collet by more than:
   A. +.02 to -.03 inch.
   B. +.002 to -.003 inch.
   C. +.03 to -.02 inch.
   D. +.003 to -.002 inch.
   E. None of the above answers is correct.

16. If cast iron face plates are used at high speeds,
   A. The workpiece will warp.
   B. The lathe will jam.
   C. The T-slots will release the workpiece.
   D. This is a trick question. Cast iron face plates are routinely used at very high speeds.
   E. None of the above answers is correct.

17. The accuracy of centricity on a four jaw chuck depends mostly on:
   A. The condition of the chuck.
   B. The sharpness of the cutting tool.
   C. The ability of the machinist.
   D. All of the above affect the accuracy of centricity.
   E. None of the above answers is correct.

18. Machinist A says that the back gears must always be engaged with the spindle under power. Machinist B says that, on variable speed drives, they should not shift gears with the engine running and the clutch engaged. Who is correct?
   A. Machinist A only
   B. Machinist B only
   C. Both technicians are correct.
   D. Neither technician is correct.

19. When using the lathe, the diameter of the workpiece is reduced by ___ the amount to which the tool is set.
   A. Exactly
   B. Twice
   C. Thrice
   D. Half
   E. None of the above answers is correct.

20. When setting up for facing or center drilling, always tighten the jaws:
   A. Where the dial indicator contacts the work.
   B. Opposite the dial indicator's work-contact point.
   C. On the drive-side first.
   D. The tightening of the jaws does not affect the machining of the workpiece.
   E. None of the above answers is correct.

21. Machinist A says that cutoff or parting tools cannot be used when turning on centers without supports. Machinist B says that partially-completed threads cannot be checked if the workpiece is taken off the lathe. Who is correct?
   A. Machinist A only
   B. Machinist B only
   C. Both technicians are correct.
   D. Neither technician is correct.

22. Why is it that the center for the headstock is not often hardened?
   A. To prevent damage to the workpiece
   B. To prevent damage to the spindle dogs
   C. To facilitate its sharpening
   D. All of the above answers are correct.
   E. None of the above answers is correct.

23. Some micrometer collars on cross feed screws read:
   A. Single depth.
   B. Double depth.
   C. Directly.
   D. All of the above answers are correct.
   E. None of the above answers is correct.

24. **Machinist A says that a workpiece may take several roughing cuts, depending on the size of the workpiece. Machinist B says that one or two finish cuts may be required, depending on the lathe. Who is correct?**

- A. Machinist A only
- B. Machinist B only
- C. Both technicians are correct.
- D. Neither technician is correct.

25. **Facing should not be done on pieces extending more than ___ times the ___ of the workpiece.**

- A. Three. . .circumference
- B. Five. . .circumference
- C. Three. . .diameter
- D. Five. . .diameter
- E. None of the above answers is correct.

26. **Machinist A says that the carriage must not be locked when taking facing cuts. Machinist B says that finer feeds, generally one-half to one-third that of longitudinal feeds, should be used when facing. Who is correct?**

- A. Machinist A only
- B. Machinist B only
- C. Both technicians are correct.
- D. Neither technician is correct.

27. **Machinist A says that center drilling requires a combination drill and countersink, usually between 1/8 and 3/4 inch body diameter. Machinist B says that such drills are classified by a numeric code from "000" to "8" which is stamped on the drill body. Who is correct?**

- A. Machinist A only
- B. Machinist B only
- C. Both technicians are correct.
- D. Neither technician is correct.

28. **If a taper is discovered while making a finish cut:**

- A. It is easily repaired by re-aligning the tailstock.
- B. It is usually too late to save the workpiece.
- C. There is *nothing* that can save the workpiece.
- D. There is nothing wrong with a slight taper in any workpiece.
- E. None of the above answers is correct.

29. A test bar is a:
   A. Shaft without tapers and that is not eccentric.
   B. Hollow bar which fits over the stocks.
   C. A relaxing place to go after a major exam.
   D. None of the above answers is correct.

30. When center drilling, the machinist should:
   A. Frequently back the drill out to remove chips.
   B. Use cutting fluid.
   C. Maintain a slow drill feed.
   D. All of the above steps are necessary for center drilling.
   E. None of the above answers is correct.

31. When making facing cuts, the point of the tool should be set:
   A. Above center.
   B. At dead center.
   C. Below center.
   D. The initial position of the tool is immaterial.
   E. None of the above answers is correct.

32. When boring,
   A. Back rake is not usually used.
   B. There must be sufficient clearance for chip dispersal.
   C. The point of the boring tool must be on center.
   D. The must be enough end relief to prevent rubbing.
   E. All of the above answers are correct.

33. Machinist A says that facing cuts taken from the center of the workpiece will give better finishes, but are difficult to make. Machinist B says that facing cuts taken from the outside can be done with heavier cuts. Who is correct?
   A. Machinist A only
   B. Machinist B only
   C. Both Machinists A and B
   D. Neither Machinist A nor B

34. A blind hole:
    A. Does not pass completely through the workpiece.
    B. Is *not* threaded.
    C. Has been machined flat.
    D. Both A and C are correct.
    E. None of the above answers is correct.

35. Using the engine of the lathe to tap internally generally requires that:
    A. The spindle rotation be reversed.
    B. A spiral point tap be used.
    C. The hole run completely through the workpiece.
    D. All of the above answers are correct.
    E. None of the above answers is correct.

36. Knurls are:
    A. Usually formed with pressure.
    B. Used to improve the grip of the user of the tool.
    C. Used to enhance part grip in low-stress applications.
    D. All of the above answers are correct.
    E. None of the above answers is correct.

37. The term "threads per inch" means:
    A. The distance between two adjacent thread crests.
    B. The distance between two adjacent thread roots.
    C. Either 15 or 30, depending on whether the threads are coarse or fine.
    D. The thickness of the machinist's gloves.
    E. None of the above answers is correct.

38. The term "pitch" means:
    A. The distance between two adjacent thread crests.
    B. The distance between two adjacent thread roots.
    C. Either 15° or 30°, depending on whether the threads are coarse or fine.
    D. The angle of thread inclination.
    E. None of the above answers is correct.

39. The term "basic thread height (or depth)" means:
   A. The difference between the major and minor diameters of the screw.
   B. The difference between the original diameter of the workpiece and the finished diameter of the screw.
   C. One-half the major diameter of the finished screw.
   D. One-half the major diameter of the rough screw.
   E. None of the above answers is correct.

40. The angle of the threads in both the older American National and the newer American Standard for Unified threads is:
   A. 30°.
   B. 45°.
   C. 60°.
   D. 75°.
   E. None of the above answers is correct.

41. The proper rake angle for cutting threads with a cross slide is:
   A. 0°.
   B. 5°.
   C. 10°.
   D. 29°.
   E. None of the above answers is correct.

42. Spindle speeds for threading are approximately ___ those of turning.
   A. Twice
   B. Equal to
   C. Half
   D. One quarter
   E. None of the above answers is correct.

43. When cutting internal threads, bellmouth can result from:
   A. Too little infeed.
   B. Too much infeed.
   C. Insufficient cutting oil.
   D. Any of the above can cause bellmouth.
   E. None of the above answers is correct.

44. To eliminate chatter marks on workpieces which extend more than four diameters beyond the chuck, the machinist should:
A. Lower the spindle speed.
B. Raise the spindle speed.
C. Lighten the cut.
D. Use a steady rest.
E. None of the above answers is correct.

45. Expansion from heating of the workpiece may require that the machinist adjust the ___ of the steady rest.
A. Lower jaws.
B. Trailing jaw.
C. Upper jaw.
D. This question is inaccurate; all steady rests automatically compensate for workpiece expansion.
E. None of the above answers is correct.

46. Steady rests should never be used on:
A. Finished surfaces.
B. First cuts.
C. Rough surfaces.
D. Both B and C are correct.
E. None of the above answers is correct.

Questions 47-50 deal with the identification of screw types by their thread patterns. You will obtain the screws from your instructor; write your answers on the following lines.

47. ____

48. ____

49. ____

50. ____

MFG-F7
Operate Metal Cutting Lathes
Self-Assessment Answer Key

1. C
2. D
3. B
4. B
5. D
6. A
7. D
8. C
9. C
10. C
11. B
12. B
13. C
14. C
15. B
16. E
17. C
18. B
19. B
20. A
21. A
22. C
23. D
24. D
25. D
26. B
27. A
28. B
29. A
30. D
31. B
32. E
33. C
34. A
35. D
36. D
37. E
38. A
39. A
40. C
41. A
42. D
43. B
44. D
45. C
46. C
47. ____________
48. ____________
49. ____________
50. ____________

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-F8

Subject: **Manufacturing Technology** **Time: 40 Hrs.**

Duty: **Perform Conventional Machining**
Task: Operate Grinding/Abrasive Machines

Objective(s):

Upon completion of this unit the student will be able to:
a. Discuss the selection and identification of grinding wheels;
b. Inspect, mount, true, dress, and balance grinding wheels;
c. Discuss common problems and solutions in surface grinding;
d. Operate horizontal spindle reciprocating table surface grinders;
e. Operate ID and OD grinders;
f. Operate honing machines; and,
g. Operate lapping machines.

Instructional Materials:

MASTER Handout (MFG-F8-HO)
MASTER Laboratory Exercise (MFG-F8-LE)
MASTER Laboratory Aid (MFG-F8-LA)
MASTER Self-Assessment
Sample grinding wheels of different abrasives
Sample grinding wheels of different forms

References:

Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition
Instructor's Manual, Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition
Student Workbook, Machine Tool Practices, Kibbe, Neely, and Meyer, Wiley Publishing, Latest Edition
Workbook for Machining Fundamentals, John R. Walker, The Goodheart-Willcox Co., Inc. Publishers, Latest Edition

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Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-A1 through MFG-A7 "Practice Safety"

MFG-B7 "Calculate Speeds and Feeds for Machining"
MFG-E3 "Measure With Hand Held Instruments"
MFG-F1 "Prepare and Plan for Machining Operations"

Introduction:

Throughout a machinist's career, he will encounter countless reasons to use grinders and other abrasive tools. Such reasons range from re-working cutting tools to forming difficult parts from certain metals.

Presentation Outline:

I. Discuss the Selection and Identification of Grinding Wheels
  A. Types of Common Abrasives
  B. Uses of Common Abrasives
  C. Coding System
  D. Types of Grinding Wheels
    1. Surface Grinders
    2. Cylindrical Grinders
II. Inspect, Mount, True, Dress, and Balance Grinding Wheels
III. Discuss Common Problems and Solutions in Surface Grinding
  A. Use and Selection of Grinding Fluids
  B. Surface Grinding is NOT Face Grinding
IV. Operate Horizontal Spindle Reciprocating Table Surface Grinders
V. Operate ID and OD Grinders
VI. Operate Honing Machines
VII. Operate Lapping Machines

Practical Application:

The student should complete the laboratory worksheet at the end of this module. The students will also be able to identify the best grinding wheel for a specific operation.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-G1) dealing with preparing and planning for CNC machining operations.

MFG-F8-HO
Operate Grinding/Abrasive Machines
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Discuss the selection and identification of grinding wheels;
- b. Inspect, mount, true, dress, and balance grinding wheels;
- c. Discuss common problems and solutions in surface grinding;
- d. Operate horizontal spindle reciprocating table surface grinders;
- e. Operate ID and OD grinders;
- f. Operate honing machines; and,
- g. Operate lapping machines.

Module Outline:

- I. Discuss the Selection and Identification of Grinding Wheels
  - A. Types of Common Abrasives
  - B. Uses of Common Abrasives
  - C. Coding System
  - D. Types of Grinding Wheels
    - 1. Surface Grinders
    - 2. Cylindrical Grinders
- II. Inspect, Mount, True, Dress, and Balance Grinding Wheels
- III. Discuss Common Problems and Solutions in Surface Grinding
  - A. Use and Selection of Grinding Fluids
  - B. Surface Grinding is NOT Face Grinding
- IV. Operate Horizontal Spindle Reciprocating Table Surface Grinders
- V. Operate ID and OD Grinders
- VI. Operate Honing Machines
- VII. Operate Lapping Machines

MFG-F8-LE
Operate Grinding/Abrasive Machines
Attachment 2: MASTER Laboratory Exercise

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1. Instructor will demonstrate how to setup and operate a surface grinder to a tolerance of .002 without endangering personnel of equipment.

2. Student will demonstrate how to setup and operate a surface grinder to a tolerance of .002 without endangering personnel of equipment.

3. Instructor will grade student's performance on setup and operating a surface grinder to a tolerance of .002 without endangering personnel of equipment.

MFG-F8-LA
Operate Grinding/Abrasive Machines
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
   a. No loose clothing, including ties;
   b. Long hair properly stowed;
   c. No jewelry;
   d. Hard, closed-toe shoes;
   e. Eye protection (safety glasses); and,
   f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name____________________________ Date________________

MFG-F8
Operate Grinding/Abrasive Machines
Self-Assessment

Circle the letter preceding the correct answer.

1. The most widely used abrasive in manufacturing, the purer grades are almost white in color. Used mostly on hardened steels, this abrasive can work poorly on cast iron because, at the temperatures generated by grinding, it may be somewhat soluble in cast iron. Which abrasive is this?
   A. Aluminum Oxide
   B. Silicon Carbide
   C. Cubic Boron Nitride
   D. Diamond
   E. None of the above answers is correct.

2. This abrasive is useful on cast iron, titanium alloys, copper alloys, and other non-ferrous alloys. While it works well on carbide cutting tools, it has largely been supplanted by another abrasive which abrades at lower temperatures. Which abrasive is this?
   A. Aluminum Oxide
   B. Silicon Carbide
   C. Cubic Boron Nitride
   D. Diamond
   E. None of the above answers is correct.

3. General Electric Company introduced this abrasive commercially in 1969. It works very well on cobalt and nickel superalloys. While the cost of this abrasive is high, it results in faster cutting, less dressing, more consistent sizing, and less frequent wheel replacement. Which abrasive is this?
   A. Aluminum Oxide
   B. Silicon Carbide
   C. Cubic Boron Nitride
   D. Diamond
   E. None of the above answers is correct.

4. A common application of this superabrasive is the single-crystal nib used to true and dress grinding wheels. It is also used on tungsten alloys and ceramics, but its extreme cost limits its use to those applications in which it is virtually the only abrasive practical. This is the hardest material known. Which abrasive is this?
   A. Aluminum Oxide
   B. Silicon Carbide
   C. Cubic Boron Nitride
   D. Diamond
   E. None of the above answers is correct.

5. Which of the following is *not* one of the five most common wheel shapes?
   A. Type 1—Straight wheel
   B. Type 4—Cylinder wheel
   C. Type 11—Flaring cup wheel with interior and exterior grinding faces
   D. All of the above are common shapes for grinding wheels.
   E. None of the above answers is correct.

All grinding wheels are marked with an alphanumeric code on the blotter. For Questions 6 through 10, refer to the following code:

B 36 — J12V

6. The first letter stands for the wheel's ___; the B stands for ___.
   A. Type of abrasive . . . silicon carbide
   B. Type of abrasive . . . cubic boron nitride
   C. Hardness . . . silicon carbide
   D. Hardness . . . cubic boron nitride
   E. None of the above answers is correct.

7. The first number stands for the ___, and can range from ___.
   A. Grit . . . 40 to 500
   B. Hardness . . . 40 to 500
   C. Grit . . . 4 to 500+
   D. Hardness . . . 4 to 500+
   E. None of the above answers is correct.

8. The second letter indicates the ___; the letters increase in hardness from ___.
   A. Strength of bond . . . F to Z
   B. Strength of bond . . . A to Z
   C. Hardness grade . . . R to Z
   D. Hardness grade . . . A to Z
   E. None of the above answers is correct.

9. The second number indicates the ___; the 12 means ___.
   A. Grit . . . coarse grade
   B. Grit . . . medium grade
   C. Grain spacing . . . open structure
   D. Grain spacing . . . dense structure
   E. None of the above answers is correct.

10. The third letter and final symbol indicates the ___. The V is ___ in the machine shop.
   A. Matrix . . . common
   B. Matrix . . . rare
   C. Bond . . . rare
   D. Bond . . . common
   E. None of the above answers is correct.

11. What is *swarf?*
   A. The fine particles that come off the workpiece when it is ground.
   B. The sparks given off by the workpiece as it is ground.
   C. The retreat of waves from the beach, the complement of *surf.*
   D. Both A & B.
   E. None of the above answers is correct.

12. Which of the following is ***not*** a factor in wheel selection?
   A. Composition of workpiece
   B. Cutting fluids
   C. Machine horsepower
   D. All of the above are factors in wheel selection.
   E. None of the above answers is correct.

13. What is meant by *trueing the wheel?*
   A. Removing the dull grains from the wheel
   B. Removing the embedded swarf from the wheel
   C. Aligning the wheel with the center of its axis of rotation
   D. Both A & B
   E. None of the above answers is correct.

14. What is meant by *dressing the wheel?*
   A. Removing the dull grains from the wheel
   B. Removing the embedded swarf from the wheel
   C. Aligning the wheel with the center of its axis of rotation
   D. Both A & B
   E. None of the above answers is correct.

15. Diamond wheels have machined bores so that:
   A. They will fit the spindle closely and truly.
   B. The grit and bond will not take up most of the wheel.
   C. They can be used on grinders of different manufacture.
   D. All of the above answers are correct.
   E. None of the above answers is correct.

16. The acceptable ratio of volume of abrasive loss to volume of workpiece removal (grinding ratio) for conventional abrasives is:
   A. 100:1.
   B. 80:1.
   C. 40:1.
   D. 20:1.
   E. None of the above answers is correct.

17. Which of the following is *not* a problem in grinding?
   A. Chatter
   B. Burning the workpiece
   C. Scratches on work
   D. All of the above are problems in grinding.
   E. None of the above answers is correct.

18. In cylindrical grinding, the workpiece is rotated ___ the rotation of the grinding wheel.
   A. By
   B. With
   C. Against
   D. The direction of relative rotation depends on the job at hand.
   E. None of the above answers is correct.

19. In general, a grinder can generate a temperature as high as ___ degrees Fahrenheit at the point of contact with the workpiece.
   A. 200
   B. 500
   C. 1000
   D. 2000
   E. None of the above answers is correct.

20. Match the following surface grinder types to their physical descriptions:
   A. Horizontal spindle with reciprocating table
   B. Vertical spindle with either reciprocating or rotary table
   C. Horizontal spindle with rotary table

Type I ___

Type II ___

Type III ___

MFG-F8
Operate Grinding/Abrasive Machines
Self-Assessment Answer Key

1.	A	
2.	B	
3.	C	
4.	D	
5.	B	
6.	B	
7.	C	
8.	A	
9.	C	
10.	D	
11.	D	
12.	D	
13.	C	
14.	D	
15.	A	
16.	C	
17.	D	
18.	C	
19.	D	
20.	Type I	A
	Type II	C
	Type III	B

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials(BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

Duty G

MFG-G1

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-G1

Subject: **Manufacturing Technology** **Time: 6 Hrs.**

Duty: **Perform Advanced Machining**
Task: Prepare and Plan For CNC Machining Operations

Objective(s):

Upon completion of this unit the student will be able to:
a. Read and interpret blueprints;
b. Understand machinability and chip formation;
c. Use the ***Machinery's Handbook*** as a reference for machine applications;
d. Describe the tools and toolholders will be needed for machining operations;
e. Calculate speeds, feeds, and depth of cut for various machine operations;
f. Use carbides and other tool materials;
g. Assemble work holding (fixturing) components; and,
h. Perform basic semi-precision and precision layout as necessary.

Instructional Materials:

MASTER Handout (MFG-G1-HO)
MASTER Laboratory Aid (MFG-G1-LA)
MASTER Self-Assessment

References:

Machinery's Handbook, Industrial Press, Latest Edition, Assorted Topics
NTMA Modules:

MA-I-03	"Blueprint Reading, Introduction"
MA-I-04	"Relative Motions Between Tool & Workpiece: Chip Formation"
MA-I-22	"Milling Machine: Speeds & Feeds/Problems"
MA-I-24	"Milling Machine: Cutters and Operations"
MA-I-32	"Engine Lathe: Cutting Tools & Fluids"
MA-I-34	"Engine Lathe: Accessories & Work Holding Devices"

MA-III-45, -49, -53, -57, -61, -65, -69, -73, -75, -77, and -79
MA-III-44, -48, -52, -56, -60, -64, and -68
"Carbide Tooling: *Assorted Topics*"

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1 through MFG-A7	"Practice Safety"
MFG-B1 through MFG-B15	"Apply Mathematical Concepts"
MFG-C1 through MFG-C10	"Interpret Engineering Drawings and Control Documents"
MFG-D1 through MFG-D6	"Recognize Different Manufacturing Materials and Processes"
MFG-E1 through MFG-E6	"Measure/Inspect"
MFG-F1 through MFG-F8	"Perform Conventional Machining"

Introduction:

With CNC machine tools rapidly becoming the machine of choice for most machining applications, it is imperative that a person entering the machinist trade learn to program, setup and operate CNC machine tools. In many ways CNC machines are similar to conventional machines. Both types of machines perform the same type of operations and must follow the same process planning steps. However, CNC machine tools have many capabilities available to the machinist which allow production of machine parts at higher production rates and higher levels of quality. When preparing to use a CNC machine tool, many of the planning and preparation steps are the same as those followed for conventional machine tools. Therefore, many of the topics covered in this lesson may be used as a reinforcement of the topics covered in the conventional machining series.

Presentation Outline:

I. Plan for CNC Machining Operation
    A. Read and interpret blueprints
    B. Understand machinability and chip formation
    C. Plan for raw material preparation
        1. Describe effect of material preparation on production
        2. Describe typical shapes of raw materials
        3. Describe effects of proper material preparation
        4. Describe ways to minimize wasted time and material
        5. Describe pre-machining of materials to avoid excessive CNC machine time
        6. Create material preparation plan for NC machining
    D. Use the ***Machinery's Handbook*** as a reference for machine applications
    E. Answer the following questions:

1. What operations are necessary to produce the part? (qualify, rough, finish, grind, face, turn, thread, groove, etc.)
2. What sequence of tools will be used?
3. How will the part be fixtured? Fasteners should not interfere with machine movement. (Clamps, vise, chucks, collets, etc.)
4. How many set-ups will be required?
5. What is the accuracy required for machining dimensions?

F. Plan use of machining fixtures
   1. Describe and identify various work holding devices
   2. Describe clamping principles and cautions
   3. Describe work piece locating principles
   4. Create plan for work holding devices and tooling selection on program planning sheet

II. Prepare for Machining Operations
   A. What type of tools and toolholders will be needed for roughing, finishing, etc.? Use carbides and other tool materials when available. Verify tool availability.
   B. Calculate speeds, feeds, and depth of cut for various machine operations
   C. Assemble work holding (fixturing) components
   D. Perform basic semi-precision and precision layout as necessary
   E. Load the part into the work-holding (fixturing) device

Practical Application:

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-G2) dealing with the selection and use of CNC tooling systems.

MFG-G1-HO
Prepare and Plan For CNC Machining Operations
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Read and interpret blueprints;
- b. Understand machinability and chip formation;
- c. Use the ***Machinery's Handbook*** as a reference for machine applications;
- d. Describe the tools and toolholders will be needed for machining operations;
- e. Calculate speeds, feeds, and depth of cut for various machine operations;
- f. Use carbides and other tool materials;
- g. Assemble work holding (fixturing) components; and,
- h. Perform basic semi-precision and precision layout as necessary.

Module Outline:

- I. Plan for CNC Machining Operation
  - A. Read and interpret blueprints
  - B. Understand machinability and chip formation
  - C. Plan for raw material preparation
    - 1. Describe effect of material preparation on production
    - 2. Describe typical shapes of raw materials
    - 3. Describe effects of proper material preparation
    - 4. Describe ways to minimize wasted time and material
    - 5. Describe pre-machining of materials to avoid excessive CNC machine time
    - 6. Create material preparation plan for NC machining
  - D. Use the ***Machinery's Handbook*** as a reference for machine applications
  - E. Answer the following questions:
    - 1. What operations are necessary to produce the part? (qualify, rough, finish, grind, face, turn, thread, groove, etc.)
    - 2. What sequence of tools will be used?
    - 3. How will the part be fixtured? Fasteners should not interfere with machine movement. (Clamps, vise, chucks, collets, etc.)
    - 4. How many set-ups will be required?
    - 5. What is the accuracy required for machining dimensions?
  - F. Plan use of machining fixtures
    - 1. Describe and identify various work holding devices

2. Describe clamping principles and cautions
3. Describe work piece locating principles
4. Create plan for work holding devices and tooling selection on program planning sheet

II. Prepare for Machining Operations

A. What type of tools and toolholders will be needed for roughing, finishing, etc.? Use carbides and other tool materials when available. Verify tool availability.

B. Calculate speeds, feeds, and depth of cut for various machine operations

C. Assemble work holding (fixturing) components

D. Perform basic semi-precision and precision layout as necessary

E. Load the part into the work-holding (fixturing) device

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name___________________________ Date_______________

MFG-G1
Prepare and Plan For CNC Machining Operations
Self-Assessment

Circle the letter preceding the correct answer.

1. The intentional difference in the sizes of mating parts is called _______________.
   A. fit
   B. tolerance
   C. allowance
   D. limits

2. The permissible variation of the size of a part is called _______________.
   A. fit
   B. tolerance
   C. allowance
   D. limits

3. The largest and smallest permissible dimensions of a part are the _______________.
   A. fit
   B. tolerance
   C. allowance
   D. limits

4. Which property of metals is directly related to machinability?
   A. Ductility
   B. Malleability
   C. Hardness
   D. Elasticity

5. Which of the following types of information can not be found in the *Machinery's Handbook*?
   A. Recommended cutting speeds
   B. Recommended feeds
   C. Table of composition of steels
   D. Table of machine tool builders

6. The RPM for machining a 1" diameter aluminum workpiece (SFM=500) is ______________.

A. 1000 RPM
B. 2000 RPM
C. 3000 RPM
D. 4000 RPM

7. Using the ASA system of identifying carbide inserts, an insert with the number of TNMG-323E; what does the "T" indicate?

A. Thickness
B. Toughness
C. The shape
D. Two sided

8. Which type of inserts are best suited for machining extremely hard workpieces?

A. Carbide
B. Cemented oxide (ceramic)
C. Cubic boron nitride
D. Diamond

9. The ______________ may be used to measure or mark off vertical distances.

A. surface gage
B. vernier height gage
C. steel rule
D. craftsman's vertical scribe

10. Which of the following is usually used to lay out arcs and circles?

A. circle template
B. radius gages
C. sine bar
D. dividers

MFG-G1
Prepare and Plan for CNC Machining Operations
Self-Assessment Answer Key

1. C
2. B
3. D
4. C
5. D
6. B
7. C
8. D
9. B
10. D

MFG-G2

MANUFACTURING TECHNOLOGY SERIES
MASTER Technical Module No. MFG-G2

Subject: **Manufacturing Technology** **Time: 2 Hrs.**

Duty: **Perform Advanced Machining**
Task: Select and Use CNC Tooling Systems

Objective(s):

Upon completion of this unit the student will be able to:

a. Understand machinability and chip formation;
b. Select proper insert materials and geometry;
c. Assemble tooling components;
d. Select correct tooling systems;
e. Identify tooling cost factors; and,
f. Identify and describe clamping principles and cautions.

Instructional Materials:

MASTER Handout (MFG-G2-HO)
MASTER Laboratory Aid (MFG-G2-LA)

References:

Machine Tool Practices, Kibbe, Neely and Meyer, Wiley Publishers, Latest Edition
Instructor's Manual, Machine Tool Practices, Kibbe, Neely and Meyer, Wiley Publishers, Latest Edition

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Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-B1 "Perform Basic Arithmetic Functions"

Introduction:

Presentation Outline:

I. Understand Machinability and Chip Formation
    A. Machinability

        1. Grain Structure
        2. Metallic composition of workpiece
    B. Chip formation
        1. Discuss the advantages of small chips vs. large chips
        2. Discuss *large rake angle* vs. *small rake angle*
        3. Discuss *positive rake angle* vs. *negative rake angle*
        4. Discuss *angle of keenness* and chipbreakers
    C. Effects of heat and friction
        1. Discuss *red hardness* (temperatures in excess of 900°F)
        2. Cemented-carbide cutting tools and temperatures up to 1600°F
        3. Discuss how friction affects final size
    D. Discuss the properties and use of cutting fluids

II. Select Proper Insert Materials and Geometry
III. Assemble Tooling Components
IV. Select Correct Tooling Systems
    A. List common types of tool alloys used for cutting tools
    B. Identify advantages and disadvantages of different alloys
    C. Evaluate prices for various alloys compared to productivity changes
    D. Compare various tool geometries and their effects on machining
    E. Select tooling based on various budget models
    F. Create tool planning list showing various models
V. Identify Tooling Cost Factors

Practical Application:

Evaluation and/or Verification:

Due to variances in tooling systems, the instructor must prepare his own Self-Assessment.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-G3) dealing with programming CNC machines.

MFG-G2-HO
Select and Use CNC Tooling Systems
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Understand machinability and chip formation;
- b. Select proper insert materials and geometry;
- c. Assemble tooling components;
- d. Select correct tooling systems;
- e. Identify tooling cost factors; and,
- f. Identify and describe clamping principles and cautions.

Module Outline:

- I. Understand Machinability and Chip Formation
  - A. Machinability
    - 1. Grain Structure
    - 2. Metallic composition of workpiece
  - B. Chip formation
    - 1. Discuss the advantages of small chips vs. large chips
    - 2. Discuss *large rake angle* vs. *small rake angle*
    - 3. Discuss *positive rake angle* vs. *negative rake angle*
    - 4. Discuss *angle of keenness* and chipbreakers
  - C. Effects of heat and friction
    - 1. Discuss *red hardness* (temperatures in excess of 900°F)
    - 2. Cemented-carbide cutting tools and temperatures up to 1600°F
    - 3. Discuss how friction affects final size
  - D. Discuss the properties and use of cutting fluids
- II. Select Proper Insert Materials and Geometry
- III. Assemble Tooling Components
- IV. Select Correct Tooling Systems
  - A. List common types of tool alloys used for cutting tools
  - B. Identify advantages and disadvantages of different alloys
  - C. Evaluate prices for various alloys compared to productivity changes
  - D. Compare various tool geometries and their effects on machining
  - E. Select tooling based on various budget models
  - F. Create tool planning list showing various models
- V. Identify Tooling Cost Factors

MFG-G2-LA
Select and Use CNC Tooling Systems
Attachment 1: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-G3

Subject: **Manufacturing Technology** **Time: 30 Hrs.**

Duty: **Perform Advanced Machining**
Task: Program CNC Machines

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify and describe essentials and safety of CNC systems;
b. Identify and describe types of CNC hardware and software;
c. Identify and describe machine axes and coordinate systems;
d. Identify and describe coordinate systems;
e. Plan and write programs for CNC mills; and,
f. Plan and write programs for CNC lathes.

Instructional Materials:

MASTER Handout (MFG-G3-HO)
MASTER Laboratory Exercise (MFG-G3-LE)
MASTER Laboratory Aid (MFG-G3-LA)
MASTER Self-Assessments (two)

References:

Computer Numerical Control, From Programming to Networking, S. C. Jonathan Lin, Delmar Publishers Inc., Latest Edition

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Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-G1 "Prepare and Plan for CNC Machining Operations"
MFG-G2 "Select and Use CNC Tooling Systems"

Introduction:

In the modern world of machining more and more companies are relying heavily on CNC machinery. This is a trend that is expected to continue into the future of Machine Technology. Many students are highly motivated to learn how to program and operate this type of equipment. It is wise to have a basic understanding of how the equipment

functions so we can have a better understanding of how to program the machine tool operations. Many of the procedures can be compared directly to their conventional machine counterparts. Most people will progress further along if they establish a solid foundation in the basic principles.

Presentation Outline:

I. Identify and Describe Essentials and Safety of CNC Systems
  A. Identify and explain essentials
    1. Define numerical control
    2. Explain history and future of CNC technology
    3. Identify basic elements of CNC system
    4. Define Computer Numerical Control (CNC)
    5. Explain advantages and limitations of CNC
    6. Identify applications of CNC technology
  B. Compare types of CNC systems
    1. Identify and describe modes on numerical control systems
    2. Explain difference between the following:
      a. Point-to-point
      b. Axial path
      c. 45° line type
      d. Linear Path
      e. Continuous path
    3. Describe CNC interpolation
    4. Identify types of CNC interpolations
    5. Explain difference between open loop and closed loop systems
    6. List benefits and problems of open and closed loop systems
  C. Demonstrate safety practices related to CNC systems
    1. Demonstrate safety practices, including:
      a. Safety guard/door interlocks
      b. Power box interlocks
      c. Tool loading and unloading
      d. Loading and unloading work holding devices
      e. Machine coolant disposal
    2. Describe/identify personal safety equipment

II. Identify and Describe Types of CNC Hardware and Software
  A. Identify and describe CNC hardware
    1. Compare NC and CNC systems
    2. Identify components of CNC machine control unit (MCU)
    3. Define applications of operator control panel
    4. Explain functions of operator control panel
    5. Define utilities found on typical control panel
    6. Select appropriate CNC controls
  B. Describe CNC software

1. Describe software related to machine tool
2. Describe applications of operation, interface and application software
3. Describe interface of software and hardware

C. Explain feed back drive system
1. Describe feed drive system
2. Explain feed back mechanisms
3. Compare direct and indirect measurement systems

III. Identify and Describe Machine Axes and Coordinate Systems

A. Identify and describe machine axes
1. Define and identify machine axes X, Y and Z
2. Identify and describe linear axes using right hand rule
3. Identify and define primary rotary axes a, b and c

B. Describe coordinate systems
1. Describe Cartesian coordinate system as used in NC program
2. Define relationship of Cartesian coordinate system with machine axes

C. Define characteristics of positioning systems
1. Define application of absolute positioning systems
2. Define application of incremental positioning systems

D. Define reference systems
1. Describe characteristics of:
   a. Machine reference coordinates
   b. Work reference coordinates
   c. Program reference coordinates
   d. Fixtures offset coordinates

IV. Describe and Interpret CNC Coding Systems

A. Interpret number bases
1. Interpret decimal and binary bases
2. Interpret octal and hexadecimal bases

B. Describe NC program storage media
1. Describe the media
2. Describe advantages and disadvantages of each media

C. Describe EIA and ASCII formatted tapes
1. Describe EIA format on tapes
2. Describe ASCII format on tapes
3. Describe differences in EIA and ASCII formats

V. Write NC Programs

A. Create NC words
1. Define NC characters, blocks and words
2. Identify and describe commonly used NC codes
3. Describe and create safe start blocks
4. Combine NC codes to create part program

B. Create NC programs
1. Use absolute (G90) and incremental (G91) positioning

2. Use rapid positioning (G00) and linear interpolation (G01)
3. Use circular interpolation (G02) and (G03)
4. Identify plane selections (G17, G18, G19)
5. Apply proper plane selection to circular interpolation
6. Define and describe axis modifiers (I, J, K) and apply to circular interpolation (absolute and incremental type)

C. Calculate and program cutter speed and cutter compensation
   1. Describe cutter compensation commands (G40, G41, G42)
   2. Describe relationships associated with G41 and climb milling
   3. Describe relationship associated with G42 and conventional milling
   4. Evaluate reference documentation to establish machinability factors for RPM equation
   5. Apply RPM calculations to identify proper spindle speed "S" word

D. Calculate and program cutter feed and depth of cut
   1. Evaluate reference documentation to establish feed rate factors
   2. Apply depth of cut calculations for programming efficiency
   3. Apply feed equation to establish correct feed "F" word

E. Program tool selection and unit input systems
   1. Describe and apply unit input code (G70 and G71) correctly
   2. Describe tool function "T" word and its use
   3. Describe retract quill to Z machine home "M6"
   5. Describe and apply "T" word with "M6" to create tool change
   6. Apply "M" codes to program
   7. Describe and list common "M" words and their applications
   8. Describe "M00" program stop and "M01" optional stop applications
   9. Describe "M02" end of program and "M30" end of tape

F. Program spindle operation
   1. Identify spindle commands
   2. Describe "M03" spindle on clockwise and "M04" spindle on counterclockwise
   3. Describe "M05" stop spindle
   4. Identify and describe coolant commands "M07", "M08" and "M09"
   5. Apply "M" codes to program

G. Program fixed cycles
   1. Identify and describe fixed cycles "G81 - G89"
   2. Describe benefits and time saving by using fixed cycles in programming
   3. Explain different fixed cycle formats for different controllers
   4. Apply fixed cycles to programs

H. Program operator messages
   1. Identify and describe non-machine code "operator messages"

2. Describe symbols to isolate operator messages from program
    a. "*"
    b. "()"
3. Apply operator messages to NC part program as needed

VI. Student Practice - Plan and Write Programs for CNC Mills
VII. Student Practice - Plan and Write Programs for CNC Lathes

Practical Application:

Students should complete CNC programming exercises for the CNC mill and the CNC lathe.

Evaluation and/or Verification:

Students should successfully complete the Self-Assessment found at the end of this lesson.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-G4) dealing with operating CNC machining centers (mills).

MFG-G3-HO
Program CNC Machines
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify and describe essentials and safety of CNC systems;
b. Identify and describe types of CNC hardware and software;
c. Identify and describe machine axes and coordinate systems;
d. Identify and describe coordinate systems;
e. Plan and write programs for CNC mills; and,
f. Plan and write programs for CNC lathes.

Module Outline:

I. Identify and Describe Essentials and Safety of CNC Systems
  A. Identify and explain essentials
    1. Define numerical control
    2. Explain history and future of CNC technology
    3. Identify basic elements of CNC system
    4. Define Computer Numerical Control (CNC)
    5. Explain advantages and limitations of CNC
    6. Identify applications of CNC technology
  B. Compare types of CNC systems
    1. Identify and describe modes on numerical control systems
    2. Explain difference between the following:
      a. Point-to-point
      b. Axial path
      c. 45° line type
      d. Linear Path
      e. Continuous path
    3. Describe CNC interpolation
    4. Identify types of CNC interpolations
    5. Explain difference between open loop and closed loop systems
    6. List benefits and problems of open and closed loop systems
  C. Demonstrate safety practices related to CNC systems
    1. Demonstrate safety practices, including:
      a. Safety guard/door interlocks
      b. Power box interlocks
      c. Tool loading and unloading
      d. Loading and unloading work holding devices
      e. Machine coolant disposal
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    2. Identify components of CNC machine control unit (MCU)
    3. Define applications of operator control panel
    4. Explain functions of operator control panel
    5. Define utilities found on typical control panel
    6. Select appropriate CNC controls
  B. Describe CNC software
    1. Describe software related to machine tool
    2. Describe applications of operation, interface and application software
    3. Describe interface of software and hardware
  C. Explain feed back drive system
    1. Describe feed drive system
    2. Explain feed back mechanisms
    3. Compare direct and indirect measurement systems
III. Identify and Describe Machine Axes and Coordinate Systems
  A. Identify and describe machine axes
    1. Define and identify machine axes X, Y and Z
    2. Identify and describe linear axes using right hand rule
    3. Identify and define primary rotary axes a, b and c
  B. Describe coordinate systems
    1. Describe Cartesian coordinate system as used in NC program
    2. Define relationship of Cartesian coordinate system with machine axes
  C. Define characteristics of positioning systems
    1. Define application of absolute positioning systems
    2. Define application of incremental positioning systems
  D. Define reference systems
    1. Describe characteristics of:
      a. Machine reference coordinates
      b. Work reference coordinates
      c. Program reference coordinates
      d. Fixtures offset coordinates
IV. Describe and Interpret CNC Coding Systems
  A. Interpret number bases
    1. Interpret decimal and binary bases
    2. Interpret octal and hexadecimal bases
  B. Describe NC program storage media
    1. Describe the media
    2. Describe advantages and disadvantages of each media
  C. Describe EIA and ASCII formatted tapes
    1. Describe EIA format on tapes
    2. Describe ASCII format on tapes

    3. Describe differences in EIA and ASCII formats
V. Write NC Programs
  A. Create NC words
    1. Define NC characters, blocks and words
    2. Identify and describe commonly used NC codes
    3. Describe and create safe start blocks
    4. Combine NC codes to create part program
  B. Create NC programs
    1. Use absolute (G90) and incremental (G91) positioning
    2. Use rapid positioning (G00) and linear interpolation (G01)
    3. Use circular interpolation (G02) and (G03)
    4. Identify plane selections (G17, G18, G19)
    5. Apply proper plane selection to circular interpolation
    6. Define and describe axis modifiers (I, J, K) and apply to circular interpolation (absolute and incremental type)
  C. Calculate and program cutter speed and cutter compensation
    1. Describe cutter compensation commands (G40, G41, G42)
    2. Describe relationships associated with G41 and climb milling
    3. Describe relationship associated with G42 and conventional milling
    4. Evaluate reference documentation to establish machinability factors for RPM equation
    5. Apply RPM calculations to identify proper spindle speed "S" word
  D. Calculate and program cutter feed and depth of cut
    1. Evaluate reference documentation to establish feed rate factors
    2. Apply depth of cut calculations for programming efficiency
    3. Apply feed equation to establish correct feed "F" word
  E. Program tool selection and unit input systems
    1. Describe and apply unit input code (G70 and G71) correctly
    2. Describe tool function "T" word and its use
    3. Describe retract quill to Z machine home "M6"
    5. Describe and apply "T" word with "M6" to create tool change
    6. Apply "M" codes to program
    7. Describe and list common "M" words and their applications
    8. Describe "M00" program stop and "M01" optional stop applications
    9. Describe "M02" end of program and "M30" end of tape
  F. Program spindle operation
    1. Identify spindle commands
    2. Describe "M03" spindle on clockwise and "M04" spindle on counterclockwise
    3. Describe "M05" stop spindle
    4. Identify and describe coolant commands "M07", "M08" and "M09"

5. Apply “M” codes to program

G. Program fixed cycles

1. Identify and describe fixed cycles “G81 - G89”
2. Describe benefits and time saving by using fixed cycles in programming
3. Explain different fixed cycle formats for different controllers
4. Apply fixed cycles to programs

H. Program operator messages

1. Identify and describe non-machine code “operator messages”
2. Describe symbols to isolate operator messages from program
   a. “*”
   b. “()”
3. Apply operator messages to NC part program as needed

VI. Student Practice - Plan and Write Programs for CNC Mills

VII. Student Practice - Plan and Write Programs for CNC Lathes

MFG-G3-LE
Program CNC Machines
Attachment 2: MASTER Laboratory Exercise

The students shall:

a. Plan and write programs for CNC mills; and,

b. Plan and write programs for CNC lathes.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

Name: ______________________ Date: ____________________

MFG-G3
Program CNC Machines
Self-Assessment No. 1

Circle the letter preceding the correct answer.

1. The definition "a system in which actions are controlled by the insertion of numerical data at some point" refers to?
   - a. Direct Numerical Control
   - b. Distributive Numerical Control
   - c. Numerical Control
   - d. Computerized Numerical Control

2. Which company is given credit for creating the first numerical control milling machine?
   - a. Rohr Industries
   - b. Massachusetts Institute of Technology
   - c. Parsons corporations
   - d. General Electric

3. The term CNC stands for?
   - a. Continuous Numerical Control
   - b. Centerline Numerical Control
   - c. Computerized Numerical Control
   - d. Computerized Numerical Counter

4. The term DNC has multiple definitions one is:
   - a. Distinct numerical control
   - b. Desired numerical control
   - c. Direct numerical control
   - d. Destination numerical control

5. The term DNC has multiple definitions another one is:
   - a. District numerical control
   - b. Distributive numerical control
   - c. Distinctive numerical control
   - d. Desired numerical control

6. Examples of basic elements of a CNC system would include;
   - a. Center drill
   - b. Milling cutters
   - c. Mouse
   - d. Part program

7. Examples of basic elements of a CNC system would include;
   a. Anilam
   b. Program input device
   c. Pocket calculator
   d. Coolant

8. Examples of basic elements of a CNC system would include;
   a. Machine control unit
   b. Outside micrometer
   c. Pencil and paper
   d. Basic understanding of mathematics

9. Examples of basic elements of a CNC system would include;
   a. Barcoding system
   b. Inside micrometer
   c. Drive systems
   d. Basic understanding of engineering drawings

10. Examples of basic elements of a CNC system would include;
   a. Machine Tool
   b. Basic theory of metal removal
   c. Dial calipers
   d. Windows operating system

11. Examples of basic elements of a CNC system would include;
   a. Clamping devices
   b. Depth micrometers
   c. Feedback systems
   d. Fine surface finishes

12. NC Systems are often referred to as:
   a. Primary memory
   b. Softwired
   c. Hardwired
   d. Secondary memory

13. CNC Systems are often referred to as:
   a. Primary memory
   b. Softwired
   c. Hardwired
   d. Secondary memory

14. Examples of advantages of CNC would include:
    a. High cost of cutting tools
    b. Increased productivity
    c. Highly attractive machines
    d. More interesting for maintenance workers

15. Examples of advantages of CNC would include:
    a. Lower number of pallets needed
    b. Increased electronics
    c. Inch and metric calibrations
    d. High accuracy and repeatability

16. Examples of advantages of CNC would include:
    a. Reduced production costs
    b. Systems require less attention
    c. Cost effective for small production runs
    d. Lower maintenance requirements

17. Examples of advantages of CNC would include:
    a. Reduced initial investment
    b. Reduced indirect operating costs
    c. Cost effective for small production runs
    d. Lower maintenance requirements

18. CNC operators have to have a higher skill level then a precision tool maker.
    a. True
    b. False

19. Examples of disadvantages (limitations) of CNC would include:
    a. High cost of cutting tools
    b. Higher productivity
    c. High initial investment
    d. High probability of human error

20. Examples of disadvantages (limitations) of CNC would include:
    a. Higher scrap rates
    b. Higher Maintenance requirements
    c. Higher machine utilization
    d. High probability of human error

21. Examples of disadvantages (limitations) of CNC would include:
    a. Not cost effective for precision parts
    b. Not cost effective for alloys
    c. Not cost effective for low production levels
    d. Not cost effective for non ferrous metals

22. CNC can only be applied to applications of chip removal.
    a. True
    b. False

23. The addition of CNC Machines guarantees increased productivity.
    a. True
    b. False

24. CNC programming has been dramatically changed by the advent of:
    a. Fiber optics
    b. CAD/CAM
    c. Space age coolants
    d. Special applications

25. The point to point control system is most often used in ________________ operations.
    a. Rough machining
    b. Pocket machining
    c. Drilling
    d. Contouring

26. The continuous-path control system is often called ________________ system.
    a. Rough machining
    b. Pocket machining
    c. Drilling
    d. Contouring

27. The continuous-path control system is limited since it can only move one axis at a time.
    a. True
    b. False

28. An example of a function of the CNC interpolator would include:
    a. Generates spindle speed calculations for efficient material removal
    b. Generates intermediate coordinate positions along the program path
    c. Generates the proper feed rate in program
    d. Generates a complete list of "G" codes as needed by the machine

29. An example of a function of the CNC interpolator would include:
    a. Computes coolant selections for machine tool as needed
    b. Computes separate tool changes as needed
    c. Computes individual axis velocities as needed
    d. Computes material finish requirements as needed

30. One example of a common interpolation would be:
    a. Metabolic
    b. Bi cubic approximation
    c. Linear
    d. Helical cubic NURB

31. One example of a common interpolation would be:
    a. Eliptoidinal
    b. Bi nurdic eliptoidinal
    c. Radius
    d. Circular

32. One significant feature of the _______________ control system is that there is no feedback signal for checking whether the programmed position has been reached.
    a. Closed loop
    b. Open loop
    c. NC
    d. CNC

33. One significant feature of the ________________ control system is that there are feedback signals that check whether the programmed position has been reached.
    a. Closed loop
    b. Open loop
    c. NC
    d. CNC

34. The _______________ control system is usually used with the point to point systems.
    a. Closed loop
    b. Open loop
    c. NC
    d. CNC

35. The __________________ control system is usually used with continuous path systems.
    a. Closed loop
    b. Open loop
    c. NC
    d. CNC

36. The acronym MCU stands for:
   a. Machine Companies Unification
   b. Machine control unit
   c. Machine control university
   d. Machine control union

37. An example of primary memory would include:
   a. Floppy disks
   b. Hard drives
   c. RAM
   d. Paper tape

38. An example of primary memory would include:
   a. Greco system
   b. DNC
   c. ROM
   d. Punch cards

39. An example of secondary memory would include:
   a. Greco system
   b. DNC
   c. ROM
   d. Hard drives

40. An example of secondary memory would include:
   a. Floppy disks
   b. Greco system
   c. RAM
   d. Paper tape

41. Machine _______________ is what allows us to reach a exact desired point coordinate.
   a. Controller
   b. Repeatability
   c. Accuracy
   d. Programming

42. Machine ______________ is what allows us to come back to an exact point coordinate time after time.
   a. Controller
   b. Repeatability
   c. Accuracy
   d. Programming

43. The ________________ measurement feedback system is free from the effects of machine backlash.
a. Indirect
b. Direct
c. Closed loop
d. Open loop

44. The ________________ measurement feedback system is affected by machine backlash.
a. Indirect
b. Direct
c. Closed loop
d. Open loop

45. The ________________ measurement feedback system is more accurate.
a. Indirect
b. Direct
c. Closed loop
d. Open loop

46. The machine axis designation by X, Y, and Z are the ______________ machine axis.
a. Tertiary linear
b. Primary linear
c. Secondary linear
d. Primary rotary

47. The machine axis designation by A, B and C are the _______________ machine axis.
a. Tertiary linear
b. Primary linear
c. Secondary linear
d. Primary rotary

48. The Cartesian coordinate system is often referred to as the _______________ coordinate system.
a. Polar
b. Secondary
c. Rectangular
d. Primary

49. The data point X -1.0, Y -2.0 is located in the number ________________ quadrant.
    a. 1
    b. 2
    c. 3
    d. 4

50. The data point X 1.0, Y 2.0 is located in the number ________________ quadrant.
    a. 1
    b. 2
    c. 3
    d. 4

51. The data point X 1.0, Y -2.0 is located in the number ________________ quadrant.
    a. 1
    b. 2
    c. 3
    d. 4

52. The data point X -1.0, Y 2.0 is located in the number ______________ quadrant.
    a. 1
    b. 2
    c. 3
    d. 4

53. The ________________ coordinate system defines the position of a point by its radius and an angle of rotation.
    a. Polar
    b. Secondary
    c. Rectangular
    d. Primary

54. If a data point was rotated 100 degrees from 0 it would be in the number ____________ quadrant.
    a. 1
    b. 2
    c. 3
    d. 4

55. If a data point was rotated 295 degrees from 0 it would be in the number ____________ quadrant.
   a. 1
   b. 2
   c. 3
   d. 4

56. If a data point was rotated 40 degrees from 0 it would be in the number ____________ quadrant.
   a. 1
   b. 2
   c. 3
   d. 4

57. If a data point was rotated 195 degrees from 0 it would be in the number ____________ quadrant.
   a. 1
   b. 2
   c. 3
   d. 4

58. In the ____________ positioning system all positions are measured from a single fixed point.
   a. Incremental
   b. Polar
   c. Rectangular
   d. Absolute

59. In the ____________ positioning system, the reference point is not fixed and moves from data point to data point.
   a. Incremental
   b. Polar
   c. Rectangular
   d. Absolute

MFG-G3

Program CNC Machines

Self-Assessment No. 1 Answer Key

1.	D
2.	C
3.	C
4.	C
5.	B
6.	D
7.	B
8.	A
9.	C
10.	A
11.	C
12.	C
13.	B
14.	B
15.	D
16.	A
17.	B
18.	B
19.	C
20.	B
21.	C
22.	B
23.	B
24.	B
25.	C
26.	D
27.	B
28.	B
29.	C
30.	C
31.	D
32.	B
33.	A
34.	B
35.	A
36.	B
37.	C
38.	C
39.	D
40.	A
41.	C
42.	B
43.	B
44.	A
45.	B
46.	B
47.	B
48.	C
49.	C
50.	A
51.	D
52.	B
53.	A
54.	B
55.	B
56.	A
57.	C
58.	D
59.	A

MFG-G3
Program CNC Machines
Self-Assessment No. 2

1. The command “G01" is an example of a NC _____________.
   - a. Address
   - b. Word
   - c. Block
   - d. Program

2. In the command “G01" the G is an example of a NC ________________.
   - a. Address
   - b. Word
   - c. Block
   - d. Program

3. “N01 G90 G80 G17" would be an example of a NC _____________.
   - a. Address
   - b. Word
   - c. Block
   - d. Program

4. A complete set of codes that would make a part would be called a(n) ____________.
   - a. Address
   - b. Word
   - c. Block
   - d. Program

CNC PROGRAMMING
Commonly used "G" and "M" Codes and Miscellaneous Codes

5. G91:
   - a. Height (tool length offset)
   - b. X, Y plane selection
   - c. Set X, Y, Z values, reset values
   - d. Incremental programming
   - e. Drill with dwell at end of "z" travel

6. G81:
   - a. Fast rapid positioning move
   - b. Optional stop, acts as M00 or disappears
   - c. Common drill cycle
   - d. Reaming cycle, stops spindle at "z" depth
   - e. Drill with dwell at end of "z" travel

7. G71:
   a. Incremental programming
   b. Metric programming
   c. Set X, Y, Z values, reset values
   d. Reaming cycle, stops spindle at "z" depth
   e. Drill with dwell at end of "z" travel

8. M06:
   a. Spindle on clockwise
   b. Spindle on counter clock
   c. Machine stop, stops everything
   d. Retract spindle to home position
   e. Kills canned cycles

9. G02:
   a. Counter clockwise arc requires axis modifiers
   b. Straight line move requires feed rate
   c. Set X, Y, Z values, reset values
   d. Cutter compensation left
   e. Clockwise arc requires axis modifiers

10. "S":
   a. Fast rapid positioning move
   b. Straight line move requires feed rate
   c. X axis modifier
   d. Spindle stop
   e. Speed

11. M00:
   a. Kill coolant
   b. Set X, Y, Z values, reset values
   c. Optional stop, acts as M00 or disappears
   d. Machine stop, stops everything
   e. Spindle stop

12. G04:
   a. X, Y axis movement
   b. Dwell
   c. Set X, Y, Z values, reset values
   d. Spindle stop
   e. Commonly stands for tool

13. G19:
    - a. X, Y axis movement
    - b. X, Y plane selection
    - c. X, Z plane selection
    - d. X, Z axis movement
    - e. Y, Z plane selection

14. G00:
    - a. Fast rapid positioning move
    - b. Bore in and out
    - c. Machine stop, stops everything
    - d. Cutter compensation left
    - e. Cancels cutter compensation

15. "I":
    - a. Incremental programming
    - b. Z axis modifier
    - c. X axis modifier
    - d. Mist coolant
    - e. Y, Z plane selection

16. G40:
    - a. Counter clockwise arc requires axis modifiers
    - b. Spindle on counter clock
    - c. Kill coolant
    - d. Kills cutter compensation
    - e. Kills canned cycles

17. M01:
    - a. Incremental programming
    - b. Optional stop, acts as M00 or disappears
    - c. End of program, stop
    - d. Mist coolant
    - e. Cutter compensation right

18. M08:
    - a. Spindle on clockwise
    - b. Mist coolant
    - c. Peck cycle, deep hole drilling
    - d. Flood coolant
    - e. Clockwise arc requires axis modifiers

19. G03:
    a. Straight line move requires feed rate
    b. Common drill cycle
    c. Clockwise arc requires axis modifiers
    d. Cutter compensation right
    e. Counter clockwise arc requires axis modifiers

20. G41:
    a. Height (tool length offset)
    b. Z axis modifier
    c. End of program, stop
    d. Cutter compensation left
    e. Cutter compensation right

21. M04:
    a. Spindle on clockwise
    b. Dwell
    c. Machine stop, stops everything
    d. Spindle on counter clockwise
    e. Spindle stop

22. G42:
    a. Counter clockwise arc requires axis modifiers
    b. Optional stop, acts as M00 or disappears
    c. Peck cycle, deep hole drilling
    d. Cutter compensation left
    e. Cutter compensation right

23. M09:
    a. Counter clockwise arc requires axis modifiers
    b. Spindle on counter clock
    c. Kill coolant
    d. Kills cutter compensation
    e. Kills canned cycles

24. G70:
    a. Incremental programming
    b. Metric programming
    c. Set X, Y, Z values, reset values
    d. Inch programming
    e. Drill with dwell at end of "z" travel

25. "F":
    a. Fast rapid positioning move
    b. Feed
    c. Common drill cycle
    d. Flood coolant
    e. Offset number (tool diameter)

26. M02:
    a. Spindle on clockwise
    b. Spindle on counter clockwise
    c. End of program, stop
    d. End of program, return to beginning of program and wait
    e. Cutter compensation right

27. G80:
    a. Counter clockwise arc requires axis modifiers
    b. Spindle on counter clock
    c. Kill coolant
    d. Kills cutter compensation
    e. Kills canned cycles

28. G82:
    a. Common mill cycle
    b. Bore in and out
    c. Peck cycle, deep hole drilling
    d. Reaming cycle, stops spindle at "z" depth
    e. Drill with dwell at end of "z" travel

29. G01:
    a. Fast rapid positioning move
    b. Straight line move requires feed rate
    c. Set X, Y, Z values, reset values
    d. Reaming cycle, stops spindle at "z" depth
    e. X, Z axis movement

30. G83:
    a. Common drill cycle
    b. Reaming cycle, stops spindle at "z" depth
    c. Peck cycle, deep hole drilling
    d. Reaming cycle, stops spindle at "z" depth
    e. Drill with dwell at end of "z" travel

31. G17:
   a. X, Y axis movement
   b. X, Y plane selection
   c. X, Z plane selection
   d. X, Z axis movement
   e. Y, Z plane selection

32. "J":
   a. Height (tool length offset)
   b. Z axis modifier
   c. Y axis modifier
   d. Z axis modifier
   e. Y, Z plane selection

33. M03:
   a. Spindle on clockwise
   b. Dwell
   c. End of program, stop
   d. Spindle stop
   e. Clockwise arc requires axis modifiers

34. G90:
   a. Incremental programming
   b. Metric programming
   c. X, Z plane selection
   d. Absolute programming
   e. Cancels cutter compensation

35. M05:
   a. Spindle on clockwise
   b. Dwell
   c. Machine stop, stops everything
   d. Spindle stop
   e. Cancels cutter compensation

36. M07:
   a. Spindle on clockwise
   b. Mist coolant
   c. Peck cycle, deep hole drilling
   d. Flood coolant
   e. Clockwise arc requires axis modifiers

37. M30:
- a. Spindle on clockwise
- b. Spindle on counter clockwise
- c. End of program, stop
- d. End of program, return to beginning of program and wait
- e. Cutter compensation right

38. "T":
- a. Height (tool length offset)
- b. Feed
- c. End of program, stop
- d. Mist coolant
- e. Commonly stands for tool

39. G18:
- a. X, Z plane movement
- b. X, Z plane selection
- c. Y, Z plane selection
- d. Y, Z axis movement
- e. X, Z axis movement

40. "K":
- a. X axis modifier
- b. Z axis modifier
- c. Y axis modifier
- d. X, Z plane selection
- e. Y, Z plane selection

41. "H":
- a. Height (tool length offset)
- b. Feed
- c. Y axis modifier
- d. Retract spindle to home position
- e. Speed

42.-
43. In the ____________ (answer to #42) positioning system, all points are measured from a fixed point or origin, and it's "G" code is _________ (answer to #43).

42.
- a. absolute
- b. incremental
- c. fast rapid position move
- d. set X,Y,Z values, reset values.

43.
- a. G91
- b. G92
- c. G90
- d. G00

44.-

45. **In the ___________ (answer to # 44) positioning system, the reference point from which the dimensions are measured is not fixed. Instead, it moves to the immediate preceding point from operation to operation. It's "G" code is ___________ (answer to #45).**

44.	**a.**	**absolute**	**45.**	**a.**	**G91**
	b.	**incremental**		**b.**	**G92**
	c.	**fast rapid position move**		**c.**	**G90**
	d.	**set X,Y,Z values, reset values.**		**d.**	**G00**

46. What is the formula for calculating spindle speeds for CNC machining in revolutions per minute?
    - a. RPM = Pi x D divided by CS x 12
    - b. RPM = CS x 12 divided by Pi x D
    - c. RPM = CS x 4 divided by Pi
    - d. None; automatically set with MDI on the CNC machine.

47. What is the formula for calculating feeds for CNC machining in inches per minute?
    - a. IPM = Pi x D divided by CS x 12
    - b. IPM = number of teeth on cutter x chip load per tooth
    - c. None; geometry set with MDI on the CNC machine.
    - d. IPM = RPM x number of teeth on cutter x chip load per tooth

48. If we saw the command G41D1 in a CNC program, we would know to check the _______________.
    - a. Cutter diameter in offset number 41
    - b. Cutter diameter in offset number G41D
    - c. Cutter diameter in offset number 1
    - d. Cutter diameter in offset number sl,1

Calculate the following RPM's and feed rates. Use your calculator and set for 3 decimal places.

	CS	DIA.	RPM	IPM =	CPT	# of Teeth
49.	250	.125	_____	_____	.002	4
50.	300	1.250	_____	_____	.0125	15
51.	325	.875	_____	_____	.003	2
52.	25	.500	_____	_____	.006	3
53.	100	.187	_____	_____	.001	6

Answer selection for the above questions. (RPM's / IPM's)

49. a. 8000.000 / 64.000
b. 7639.437 / 61.115
c. 119.366 / 0.955

50. a. 916.732 / 171.887
b. 1432.394 / 268.574
c. 960.000 / 180.000

51. a. 1418.753 / 8.513
b. 2.749 / 0.016
c. 1485.714 / 8.914

52. a. 2000.000 / 3.600
b. 190.986 / 3.438
c. 1884.956 / 33.929

53. a. 20159.953 / 120.960
b. 2139.037 / 12.834
c. 2042.630 / 12.256

MFG-G3
Program CNC Machines
Self-Assessment No. 2 Answer Key

1.	B
2.	A
3.	C
4.	D
5.	D
6.	C
7.	B
8.	D
9.	E
10.	E
11.	D
12.	B
13.	E
14.	A
15.	C
16.	D
17.	B
18.	D
19.	E
20.	D
21.	D
22.	E
23.	C
24.	D
25.	B
26.	C
27.	E
28.	E
29.	B
30.	C
31.	B
32.	C
33.	A
34.	D
35.	D
36.	B
37.	D
38.	E
39.	B
40.	B
41.	A
42.	A
43.	C
44.	B
45.	A
46.	B
47.	D
48.	C
49.	B
50.	A
51.	A
52.	B
53.	C

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-G4

Subject: **Manufacturing Technology** **Time: 50 Hrs.**

Duty: **Perform Advanced Machining**
Task: Operate CNC Machining Centers (Mills)

Objectives:

Upon completion of this module the student will be able to:
a. Describe history of vertical machining;
b. Describe theory of operation;
c. Describe nomenclature used in vertical machining;
d. Demonstrate safety practices related to vertical machining centers;
e. Set-up and program operation of vertical machine;
f. Demonstrate proper machining of objects;
g. Create program using machine controllers software, and cycles;
h. Set-up and utilize three dimensional digitizer; and,
i. Maintain vertical machine.

Instructional Materials:

MASTER Handout (MFG-G4-HO)
MASTER Laboratory Exercise/Self-Assessment (MFG-G4-LE/SA)
MASTER Laboratory Aid (MFG-G4-LA)

References:

Computer Numerical Control, From Programming to Networking, S.C. Jonathan Lin, Delmar Publishers, Inc., Latest Edition
Programming and Operation Manuals for your CNC machine(s)

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-G1 "Prepare and Plan for CNC Machining Operations"
MFG-G2 "Select and Use CNC Tooling Systems"
MFG-G3 "Program CNC Machines"

Introduction:

With the introduction of the first NC machines, machining was changed forever. In the beginning, ownership of NC machines was limited to those companies that possessed great financial resources. The need for these machines, even if one had the capital, was limited to those companies that produced long production runs that required little (if any) design variation. These early machines were not user friendly nor were they quick to program, set up or operate. The advent of modern computers along with major changes in associated electronics has changed this scenario forever. Today the vast majority of companies have at least one CNC machine if not many. Most of the new employment is offered in the use and programming of these machines. It is no longer an option as to whether a machinist wants to learn how to use a CNC machining center. The overall popularity of CNC machines is increasing dramatically and this trend demands that all machinists accept CNC as they have any other tool of their trade.

This module addresses the application of the CNC vertical machining center, which is really just a hybrid of the common milling machine, with the addition of many of its attachments.

This module can be used for individuals who will be using vertical machines at various levels from CNC operator to CNC machinists. The ability to complete these tasks both quickly and accurately in various settings will, in most cases, be one of the deciding factors of how long an individual will stay at the operator level or progress into the programming area.

Presentation Outline:

I. Describe Vertical Machining Process and Safety
    A. Describe History of Vertical Machining
        1. Describe proper use of various machines
    B. Describe Theory of Operation
        1. Describe open and closed loop systems
        2. Describe various oil and air requirements
        3. Describe how vertical machines function
    C. Describe Nomenclature Used in Vertical Machining
        1. Describe common tools used to:
            a. Mill
            b. Single point thread
            c. Drill
            d. Single point bore
            e. Tap
            f. Reaming
        2. Describe solid and collet type tool holders

- D. Demonstrate Safety Practices Related to Vertical Machining Centers
  - 1. Demonstrate operating safety practices, including:
    - a. Safety door interlocks
    - b. Machining vise loading and unloading
    - c. Power box interlocks
    - d. Machine coolant disposal
    - e. Tool loading and unloading
  - 2. Describe/identify personal safety equipment

II. Describe Vertical Machining Functions

- A. Describe Controller Functions, including:
  - 1. Power meter
  - 2. Automatic mode
  - 3. Key lock
  - 4. Emergency stop button
  - 5. Option switches
  - 6. Manual modes:
    - a. Command mode
    - b. MDI mode
  - 7. Rapid travel over ride
  - 8. Single step mode (Block-To-Block)
  - 9. Feed rate override
  - 10. Jog mode
  - 11. Spindle speed override
  - 12. Spindle On/Off
  - 13. Axis selector
  - 14. Slide hold
  - 15. Increment of movement selector
  - 16. Coolant 1 and 2 On/Off
  - 17. Tool In/Out
  - 18. Start button
  - 19. Turret clockwise (CW) and turret counterclockwise (CCW)
  - 20. Start function

III. Set-Up and Program Operation of Vertical Machine

- A. Describe machine tool limitations, including:
  - 1. Number of possible tools
  - 2. Limits in X,Y and Z axes
  - 3. Maximum spindle speed and horsepower
  - 4. Memory size in controller
  - 5. Fast feed rate
  - 6. Oil and air requirements
  - 7. Rapid positioning rate
  - 8. Communication systems
- B. Perform basic machine set-up
  - 1. Check oil and air supply
  - 2. Set tool changer numbers

        3. Turn power on
        4. Mount machine vise on machine table
        5. Set machine home position
        6. Indicate vise to within specified tolerances
        7. Load tools into proper tool holders
        8. Load part into vise
        9. Load tools into tool carousel
            a. Load tools using spindle
            b. Load tools directly into carousel
    C. Set part home
        1. Set part home using edge finder
        2. Set part home using test indicator and gauge block
        3. Set part home from tooling ball using fixture offsets
    D. Set tool length offsets
        1. Set tool length offsets using work piece
        2. Set tool length offsets using gauge block
        3. Set tool length offsets using electronic probe
        4. Set tool length offsets using keyboard commands
        5. Modify length and diameter offsets using tool page editor.
        6. Upload and download tool information to storage
    E. Load program
        1. Upload and download programs using RS-232 interface
        2. Upload and download programs using local area network
    F. Edit program for machine tool
        1. Edit program at machine tool using editor in controller
        2. Edit program using DOS and Windows editors
    G. Create program without CAD/CAM for common machine operations using machine controllers software to include:
        1. Proper use of cutter compensation
        2. Fixed cycles
        3. Fixed sub-routines
        4. Sub-routines (loops)
        5. Fixture offsets
        6. Trouble shoot and repair problems in programs
        7. Use machine verification options if available
IV. Demonstrate Machining of Objects on Vertical Machining Center
    A. Machine objects, including:
        1. Outside contours
        2. Pockets
        3. Drilled holes
        4. Drill and tapped holes
            a. Rigid tapping
            b. Compression tapping
        5. Single point boring
        6. Reaming

    7. Single point thread, internal and external

B. Set-up three dimensional digitizer and machine model
    1. Mount model on machine table
    2. Install 3-dimensional digitizing unit
    3. Establish communications with computer
    4. Define grid pattern and feed rate required for given tolerances
    5. Set part home
    6. Digitize model
    7. Process digital data for machining
    8. Machine new model with program created from digitizer

C. Create work piece using 4th- and 5th-axes
    1. Mount, connect and indicate 4th- and 5th-axes attachment
    2. Set-tooling
    3. Machine work piece
    4. Remove 4th- and 5th-axes attachment

D. Maintain vertical machine
    1. Mix coolant
    2. Determine need for coolant change
    3. Change coolant
    4. Clean coolant tank
    5. Clean machine
    6. Change oil filters
    7. Add lubricating fluid
    8. Add hydraulic fluid
    9. Dispose of coolant and oils per EPA regulations

Practical Application:

In our program we have found it very important to require the students to do all aspects of vertical machining. It should be obvious that if an individual cannot set up a machine, then he will be limited to just "pushing buttons."

We have developed this module for not only a specific group of individuals but also many different types of machines/controllers as well as local manufacturer requirements.

Most of the sections of this module are generic to all vertical machines as well as most machine controllers. Please note that there can be a great variation from one machine type to another; this becomes very evident in many of the sections covered in this module.

It is very important that the instructor design projects that are progressive in the level of required sophistication, so that the students will be reinforced as to their ability to complete these requirements.

Evaluation and/or Verification:

As with the Practical Application section above it will be necessary for you to design an evaluation instrument that best suits the environment in which you are presenting this information.

It is important to remember that the subject mastery is represented in the ability to not only perform the application of the technology, but also the ability to explain the process in both oral and written format.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-G5) dealing with operating CNC turning centers (lathes).

MFG-G4-HO
Operate CNC Machining Centers (Mills)
Attachment 1: MASTER Handout

Objectives:

Upon completion of this module the student will be able to:

- a. Describe history of vertical machining;
- b. Describe theory of operation;
- c. Describe nomenclature used in vertical machining;
- d. Demonstrate safety practices related to vertical machining centers;
- e. Set-up and program operation of vertical machine;
- f. Demonstrate proper machining of objects;
- g. Create program using machine controllers software, and cycles;
- h. Set-up and utilize three dimensional digitizer; and,
- i. Maintain vertical machine.

Module Outline:

- I. Describe Vertical Machining Process and Safety
  - A. Describe History of Vertical Machining
    - 1. Describe proper use of various machines
  - B. Describe Theory of Operation
    - 1. Describe open and closed loop systems
    - 2. Describe various oil and air requirements
    - 3. Describe how vertical machines function
  - C. Describe Nomenclature Used in Vertical Machining
    - 1. Describe common tools used to:
      - a. Mill
      - b. Single point thread
      - c. Drill
      - d. Single point bore
      - e. Tap
      - f. Reaming
    - 2. Describe solid and collet type tool holders
  - D. Demonstrate Safety Practices Related to Vertical Machining Centers
    - 1. Demonstrate operating safety practices, including:
      - a. Safety door interlocks
      - b. Machining vise loading and unloading
      - c. Power box interlocks
      - d. Machine coolant disposal
      - e. Tool loading and unloading
    - 2. Describe/identify personal safety equipment
- II. Describe Vertical Machining Functions

- A. Describe Controller Functions, including:
  - 1. Power meter
  - 2. Automatic mode
  - 3. Key lock
  - 4. Emergency stop button
  - 5. Option switches
  - 6. Manual modes:
    - a. Command mode
    - b. MDI mode
  - 7. Rapid travel over ride
  - 8. Single step mode (Block-To-Block)
  - 9. Feed rate override
  - 10. Jog mode
  - 11. Spindle speed override
  - 12. Spindle On/Off
  - 13. Axis selector
  - 14. Slide hold
  - 15. Increment of movement selector
  - 16. Coolant 1 and 2 On/Off
  - 17. Tool In/Out
  - 18. Start button
  - 19. Turret clockwise (CW) and turret counterclockwise (CCW)
  - 20. Start function

- III. Set-Up and Program Operation of Vertical Machine
  - A. Describe machine tool limitations, including:
    - 1. Number of possible tools
    - 2. Limits in X,Y and Z axes
    - 3. Maximum spindle speed and horsepower
    - 4. Memory size in controller
    - 5. Fast feed rate
    - 6. Oil and air requirements
    - 7. Rapid positioning rate
    - 8. Communication systems
  - B. Perform basic machine set-up
    - 1. Check oil and air supply
    - 2. Set tool changer numbers
    - 3. Turn power on
    - 4. Mount machine vise on machine table
    - 5. Set machine home position
    - 6. Indicate vise to within specified tolerances
    - 7. Load tools into proper tool holders
    - 8. Load part into vise
    - 9. Load tools into tool carousel
      - a. Load tools using spindle
      - b. Load tools directly into carousel

C. Set part home
   1. Set part home using edge finder
   2. Set part home using test indicator and gauge block
   3. Set part home from tooling ball using fixture offsets

D. Set tool length offsets
   1. Set tool length offsets using work piece
   2. Set tool length offsets using gauge block
   3. Set tool length offsets using electronic probe
   4. Set tool length offsets using keyboard commands
   5. Modify length and diameter offsets using tool page editor.
   6. Upload and download tool information to storage

E. Load program
   1. Upload and download programs using RS-232 interface
   2. Upload and download programs using local area network

F. Edit program for machine tool
   1. Edit program at machine tool using editor in controller
   2. Edit program using DOS and Windows editors

G. Create program without CAD/CAM for common machine operations using machine controllers software to include:
   1. Proper use of cutter compensation
   2. Fixed cycles
   3. Fixed sub-routines
   4. Sub-routines (loops)
   5. Fixture offsets
   6. Trouble shoot and repair problems in programs
   7. Use machine verification options if available

IV. Demonstrate Machining of Objects on Vertical Machining Center

A. Machine objects, including:
   1. Outside contours
   2. Pockets
   3. Drilled holes
   4. Drill and tapped holes
      a. Rigid tapping
      b. Compression tapping
   5. Single point boring
   6. Reaming
   7. Single point thread, internal and external

B. Set-up three dimensional digitizer and machine model
   1. Mount model on machine table
   2. Install 3-dimensional digitizing unit
   3. Establish communications with computer
   4. Define grid pattern and feed rate required for given tolerances
   5. Set part home
   6. Digitize model
   7. Process digital data for machining

    8. Machine new model with program created from digitizer

C. Create work piece using 4th- and 5th-axes
    1. Mount, connect and indicate 4th- and 5th-axes attachment
    2. Set-tooling
    3. Machine work piece
    4. Remove 4th- and 5th-axes attachment

D. Maintain vertical machine
    1. Mix coolant
    2. Determine need for coolant change
    3. Change coolant
    4. Clean coolant tank
    5. Clean machine
    6. Change oil filters
    7. Add lubricating fluid
    8. Add hydraulic fluid
    9. Dispose of coolant and oils per EPA regulations

MFG-G4-LE/SA

Operate CNC Machining Centers (Mills)

Attachment 2: **MASTER** Laboratory Exercise/Self-Assessment

Note to the Instructor:

Because of the wide variety of CNC machining centers and CNC mills available, student laboratory and assessment activities must be developed by the instructor for his or her particular laboratory equipment. All laboratory exercises and student assessments should be "hands on" which stress machine safety and assess the student's mastery of each of the lesson objectives.

MFG-G4-LA
Operate CNC Machining Centers (Mills)
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-G5

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-G5

Subject:	**Manufacturing Technology**	**Time: 50 Hrs.**
Duty:	**Perform Advanced Machining**	
Task:	Operate CNC Turning Centers (Lathes)	

Objectives:

Upon completion of this module the student will be able to:

a. Describe history of horizontal turning centers;
b. Describe theory of operation;
c. Describe nomenclature used in horizontal turning centers;
d. Demonstrate safety practices related to horizontal turning centers;
e. Set-up and program operation of horizontal turning centers;
f. Demonstrate proper machining of objects;
g. Create program using machine controllers software; and,
h. Maintain horizontal turning centers.

Instructional Materials:

MASTER Handout (MFG-G5-HO)
MASTER Laboratory Exercise/Self Assessment (MFG-G5-LE/SA)
MASTER Laboratory Aid (MFG-G5-LA)

References:

Computer Numerical Control, From Programming to Networking, S.C. Jonathan Lin, Delmar Publishers Inc., Latest Edition
Programming Manual for your CNC Machine, Latest Edition

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-G1	"Prepare and Plan for CNC Machining Operations"
MFG-G2	"Select and Use CNC Tooling Systems"
MFG-G3	"Program CNC Machines"
MFG-G4	"Operate CNC Machining Centers (Mills)"

Introduction:

With the introduction of the first NC machines, machining was changed forever. In the beginning, ownership of NC machines was limited to those companies that possessed great financial resources. The need for these machines, even if one had the capital, was limited to those companies that produced long production runs that required little (if any) design variation. These early machines were not user friendly nor were they quick to program, set up or operate. The advent of modern computers along with major changes in associated electronics has changed this scenario forever. Today the vast majority of companies have at least one CNC machine if not many. Most of the new employment is offered in the use and programming of these machines. It is no longer an option as to whether a machinist wants to learn how to use a CNC machining center. The overall popularity of CNC machines is increasing dramatically and this trend demands that all machinists accept CNC as they have any other tool of their trade.

This module addresses the application of the CNC turning center, which is really just a hybrid of the common lathe, its conventional counterpart with the addition of many of its attachments.

This module can be used for individuals who will be using turning centers at various levels from CNC operator to CNC machinists. The ability to complete these tasks both quickly and accurately in various settings will, in most cases, be one of the deciding factors of how long an individual will stay at the operator level or progress into the programming area.

Presentation Outline:

I. Explain CNC Turning Process, Equipment and Safety
    A. Describe CNC turning process
        1. Describe history of CNC turning
        2. Describe use of various turning machines
    B. Describe theory of operation
        1. Describe open and closed loop systems
        2. Describe various oil and air requirements
        3. Describe how turning centers function
    C. Describe nomenclature used in CNC turning
        1. Describe and identify common tools used to:
            a. Turn
            b. Drill
            c. Groove
            d. Face
            e. Bore
            f. Single point thread

        - g. Tap
    - 2. Describe and identify work holding devices used in turning, including:
        - a. 2-jaw chucks
        - b. 3-jaw chuck
        - c. 4-jaw chucks
        - d. Soft jaw chucks
        - e. Bar feed attachments
        - f. Collets
        - g. Centers
    - 3. Select proper cutting inserts relative to:
        - a. Roughing
        - b. Finishing
        - c. Threading
        - d. Different types of materials
- D. Demonstrate safety practices related to CNC turning centers
    - 1. Demonstrate operating safety practices, including:
        - a. Safety door interlocks
        - b. Power box interlocks
        - c. Tool loading and unloading
        - d. Loading and unloading work holding devices
        - e. Machine coolant disposal
    - 2. Describe/identify personal safety equipment

II. Describe CNC Turning Center

- A. Describe controller functions, including:
    - 1. Power meter
    - 2. Option switches
    - 3. Key lock
    - 4. Emergency stop button
    - 5. Rapid travel override
    - 6. Feed rate override
    - 7. Spindle speed override
    - 8. Axis selector
    - 9. Increment of movement selector
    - 10. Slide hold
    - 11. Start function
- B. Describe keyboard functions, including:
    - 1. Automatic mode
    - 2. Manual MDI mode
    - 3. Single step mode (block-to-block)
    - 4. Jog mode
    - 5. Spindle on/off
    - 6. Coolant on/off
    - 7. Tool turret clockwise (CW) and tool turret counterclockwise (CCW)

- III. Set-Up and Program Operation of CNC Turning Center
  - A. Describe machine tool limitations, including:
    - 1. Number of possible tools
    - 2. Maximum spindle speed and horsepower
    - 3. Fast feed rate
    - 4. Rapid positioning rate
    - 5. Limits in X and Z axes
    - 6. Memory size in controller
    - 7. Oil and air requirements
    - 8. Communication systems
  - B. Perform basic machine set-up
    - 1. Check oil and air supply
    - 2. Turn power on
    - 3. Set machine home position
    - 4. Load tools into proper tool holders
    - 5. Load tools into tool carousel
    - 6. Set tool changer numbers
    - 7. Mount work piece into chuck
    - 8. Indicate work piece within specified tolerances
  - C. Set tool length offsets
    - 1. Set tool length offsets using work piece
    - 2. Set tool length offsets using keyboard commands
    - 3. Modify length and diameter offsets using tool page editor
    - 4. Modify length and diameter offsets using keyboard
    - 5. Upload and download tool information to storage
  - D. Load program
    - 1. Upload and download programs using RS-232 interface
    - 2. Upload and download programs using local area network
  - E. Edit program for machine tool
    - 1. Edit program at machine tool using editor in controller
    - 2. Edit program using DOS and Windows editors
- IV. Create Program Without CAD/CAM for Common Machine Operations Using Machine Controllers Software to include:
  - A. Proper use of cutter compensation
  - B. Fixed cycles
  - C. Fixed sub-routines
  - D. Sub-routines (loops)
  - E. Fixture offsets
  - F. Trouble shoot and repair problems in programs
  - G. Use machine verification options if available
- V. Create Program for Common Machine Operations
  - A. Use machine controller editor
  - B. Use DOS editor
  - C. Use Windows editor
- VI. Demonstrate Machining of Objects on CNC Turning Center

A. Machine objects, including:
    1. External and internal contouring
    2. External and internal grooving
    3. Drill and tapped holes
    4. Single point boring
    5. Reaming
    6. Single point thread internal and external
    7. Facing operations
    8. Turning tapers

B. Maintain turning center
    1. Mix coolant
    2. Determine need for coolant change
    3. Change coolant
    4. Clean coolant tank
    5. Clean machine
    6. Change oil filters
    7. Add lubricating fluid
    8. Add hydraulic fluid
    9. Dispose of coolant and oils per EPA regulations

Practical Application:

In our program we have found it very important to require the students to do all aspects of vertical machining. It should be obvious that if an individual cannot set up a machine, then he will be limited to just "pushing buttons."

We have developed this module for not only a specific group of individuals but also many different types of machines/controllers as well as local manufacturer requirements.

Most of the sections of this module are generic to all vertical machines as well as most machine controllers. Please note that there can be a great variation from one machine type to another; this becomes very evident in many of the sections covered in this module.

It is very important that the instructor design projects that are progressive in the level of required sophistication, so that the students will be reinforced as to their ability to complete these requirements.

Evaluation and/or Verification:

As with the Practical Application section above it will be necessary for you to design an evaluation instrument that best suits the environment in which you are presenting this information.

It is important to remember that the subject mastery is represented in the ability to not only perform the application of the technology, but also the ability to explain the process in both oral and written format.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-G6) dealing with programming CNC machines using a CAM system.

MFG-G5-HO
Operate CNC Turning Centers (Lathes)
Attachment 1: MASTER Handout

Objectives:

Upon completion of this module the student will be able to:

a. Describe history of horizontal turning centers;
b. Describe theory of operation;
c. Describe nomenclature used in horizontal turning centers;
d. Demonstrate safety practices related to horizontal turning centers;
e. Set-up and program operation of horizontal turning centers;
f. Demonstrate proper machining of objects;
g. Create program using machine controllers software; and,
h. Maintain horizontal turning centers.

Module Outline:

I. Explain CNC Turning Process, Equipment and Safety
    A. Describe CNC turning process
        1. Describe history of CNC turning
        2. Describe use of various turning machines
    B. Describe theory of operation
        1. Describe open and closed loop systems
        2. Describe various oil and air requirements
        3. Describe how turning centers function
    C. Describe nomenclature used in CNC turning
        1. Describe and identify common tools used to:
            a. Turn
            b. Drill
            c. Groove
            d. Face
            e. Bore
            f. Single point thread
            g. Tap
        2. Describe and identify work holding devices used in turning, including:
            a. 2-jaw chucks
            b. 3-jaw chuck
            c. 4-jaw chucks
            d. Soft jaw chucks
            e. Bar feed attachments
            f. Collets
            g. Centers

3. Select proper cutting inserts relative to:
  a. Roughing
  b. Finishing
  c. Threading
  d. Different types of materials
D. Demonstrate safety practices related to CNC turning centers
1. Demonstrate operating safety practices, including:
  a. Safety door interlocks
  b. Power box interlocks
  c. Tool loading and unloading
  d. Loading and unloading work holding devices
  e. Machine coolant disposal
2. Describe/identify personal safety equipment

II. Describe CNC Turning Center
A. Describe controller functions, including:
1. Power meter
2. Option switches
3. Key lock
4. Emergency stop button
5. Rapid travel override
6. Feed rate override
7. Spindle speed override
8. Axis selector
9. Increment of movement selector
10. Slide hold
11. Start function
B. Describe keyboard functions, including:
1. Automatic mode
2. Manual MDI mode
3. Single step mode (block-to-block)
4. Jog mode
5. Spindle on/off
6. Coolant on/off
7. Tool turret clockwise (CW) and tool turret counterclockwise (CCW)

III. Set-Up and Program Operation of CNC Turning Center
A. Describe machine tool limitations, including:
1. Number of possible tools
2. Maximum spindle speed and horsepower
3. Fast feed rate
4. Rapid positioning rate
5. Limits in X and Z axes
6. Memory size in controller
7. Oil and air requirements
8. Communication systems

B. Perform basic machine set-up
   1. Check oil and air supply
   2. Turn power on
   3. Set machine home position
   4. Load tools into proper tool holders
   5. Load tools into tool carousel
   6. Set tool changer numbers
   7. Mount work piece into chuck
   8. Indicate work piece within specified tolerances

C. Set tool length offsets
   1. Set tool length offsets using work piece
   2. Set tool length offsets using keyboard commands
   3. Modify length and diameter offsets using tool page editor
   4. Modify length and diameter offsets using keyboard
   5. Upload and download tool information to storage

D. Load program
   1. Upload and download programs using RS-232 interface
   2. Upload and download programs using local area network

E. Edit program for machine tool
   1. Edit program at machine tool using editor in controller
   2. Edit program using DOS and Windows editors

IV. Create Program Without CAD/CAM for Common Machine Operations Using Machine Controllers Software to include:

A. Proper use of cutter compensation
B. Fixed cycles
C. Fixed sub-routines
D. Sub-routines (loops)
E. Fixture offsets
F. Trouble shoot and repair problems in programs
G. Use machine verification options if available

V. Create Program for Common Machine Operations

A. Use machine controller editor
B. Use DOS editor
C. Use Windows editor

VI. Demonstrate Machining of Objects on CNC Turning Center

A. Machine objects, including:
   1. External and internal contouring
   2. External and internal grooving
   3. Drill and tapped holes
   4. Single point boring
   5. Reaming
   6. Single point thread internal and external
   7. Facing operations
   8. Turning tapers

B. Maintain turning center

1. Mix coolant
2. Determine need for coolant change
3. Change coolant
4. Clean coolant tank
5. Clean machine
6. Change oil filters
7. Add lubricating fluid
8. Add hydraulic fluid
9. Dispose of coolant and oils per EPA regulations

MFG-G5-LE/SA

Operate CNC Turning Centers (Lathes)

Attachment 2: **MASTER** Laboratory Exercise/Self-Assessment

Note to the Instructor:

Because of the wide variety of CNC machining centers and CNC mills available, student laboratory and assessment activities must be developed by the instructor for his or her particular laboratory equipment. All laboratory exercises and student assessments should be "hands on" which stress machine safety and assess the student's mastery of each of the lesson objectives.

MFG-G5-LA
Operate CNC Turning Centers (Lathes)
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-G6

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-G6

Subject: **Manufacturing Technology** **Time: 30-50 Hrs.**

Duty: Perform Advanced Machining
Task: Program CNC Machines Using a CAM System

Objectives:

Upon completion of this unit the student will be able to:

1. Access CAD program options; and,
2. Create basic geometric entities.

Instructional Materials:

MASTER Handout (MFG-G6-HO)
MASTER Laboratory Aid (MFG-G6-LA)

References:

There are not many books available that discuss CAD/CAM with an emphasis on CAM, but normally there is an instructional manual that comes with the purchase of the software packages.

In the area of CAD there are many after market books available. Please check to see what is available for your software.

If you are using either MasterCam or SurfCam, there is now an aftermarket book for each. To get more information about these books contact:

Dr. Su-Chen Jonathan Lin
Scholars International Publishing Corporation
2675 Georgetown Blvd.
Ann Arbor, MI. 48105
Telephone: (313) 930-0813
Fax. Number: (313) 741-1927

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-G1 "Prepare and Plan for CNC Machining Operations"
MFG-G2 "Select and Use CNC Tooling Systems"
MFG-G3 "Program CNC Machines"

MFG-G4 "Operate CNC Machining Centers (Mills)"
MFG-G5 "Operate CNC Turning Centers (Lathes)"

Introduction:

Part I:

In this module we will discuss the actual use of CAD/CAM software to create electronic images. For those students who are using MasterCam you will notice that the information listed in the outline below relates directly to the menu commands in MasterCam.

For those of you who are not using MasterCam, your software will have menu selections that, although they are not the exactly the same as the ones listed in the outline below, they will have similar commands to perform the same type operations.

Also for anyone using either MasterCam or SurfCam, I would recommend the book listed in the resource section of this outline written by Dr. Jonathan Lin.

For those of you who are using some other company's software, there should be some type of written information that will allow you to become familiar with the basic operations listed below.

Part II:

There is no doubt that in the long term CAD/CAM saves a tremendous amount of time, and is much more flexible than paper drawings. Having made this statement it is important to note that the process of using CAD/CAM software to generate designs is a process that can be very time consuming. There is no automatic design creation that I am aware of as of this writing. Using computers to create designs is like everything else: it takes practice to become good at it.

The outline listed below covers the basic geometric elements used in creating designs. This outline only discusses wire frame geometry creation; it does not discuss either surface modeling or solid modeling. Wire frame design, although not as sophisticated as surfaces and solid modeling, encompasses the building blocks that will be used later on in more advanced CAD designs.

In CNC/CAM, we are interested in CAD as a method of generating the necessary geometric entities that will allow us to guide a cutting tool along a defined boundary or a set of boundaries to create the necessary information that will control the actions of a CNC machine tool to create a machined part to given specifications.

When we have completed the CAD component, we are only getting started. We then have to complete the CAM component as required to move onto the CNC machine.

In the overall process of CAD/CAM/CNC, the CAD section can often consume a vast majority of the time used in completion of a manufactured object. The ability to create a quality design in a short amount of time is definitely an important part of the complete process.

Presentation Outline:

- I. Access CAD Program Options
  - A. Explain the configuration of CAD/CAM software
    - 1. Explain configuration of:
      - a File and path names
      - b. Installation, including DOS and Windows
      - c. Configure software
      - d. Interaction of files between each other
    - 2. Describe the "flow" process of CAD/CAM
  - B. Access CAD software
    - 1. Access CAD software, including AutoCAD and CadKey, to:
      - a. Create basic 2-dimensional designs
      - b. Create 3-dimension designs
      - c. Dimension designs to be used as drawings
      - d. Create title blocks and borders for prints
      - e. Print drawings
      - f. Plot drawings
      - g. Create general and local drawing notes and tolerances
    - 2. Describe various file conversion formats
    - 3. Import and export designs using conversions, including:
      - a. IGES
      - b. CADL
      - c. DXF
      - d. STL
  - C. Access CAM software
    - 1. Load existing design
    - 2. Import and export design files from various file format standards, including:
      - a. IGES
      - b. DXF
      - c. CADL
      - d. STL
    - 3. Save design files to "permanent" memory
    - 4. Access CAD section of CAM software to create
      - a. Create basic 2-dimensional designs

b. Create 3-dimension designs
c. Dimension designs to be used as drawings
d. Create title blocks and borders for prints
e. Print drawings
f. Plot drawings
g. Create general and local drawing notes and tolerances

II. Create Basic Geometric Entities
A. Create basic geometric entities, including:
1. Points
2. Fillets
3. Lines
4. Splines
5. Arcs
6. Chamfers
7. Circles
8. Letters including various machinable fonts
B. Dimension completed designs to create detailed drawings
C. Transform geometric entities using CAD commands
1. Transform geometric entities, including:
a. Mirror entities
b. Rotate entities
c. Scale complete entities using single scale option
d. Translate using move and copy options
e. Offset single and grouped geometric entities
f. Use group function to effect multiple entities simultaneously
g. Use result function to effect group movements
D. Set menu selections to:
1. View planes
2. Construction planes
3. Color choices
E. Use Delete command:
1. Use Delete commands, including:
a. Chained and duplicate entities
b. Exclusive entities (only)
c. Inclusive entities (all)
d. Enclosed in window
e. Intersecting window
F. Execute screen and display functions
1. Use screen and display functions to:
a. List screen statistics
b. Display entity endpoints
c. Clear group and result color designation
d. Change colors of entities
e. Display window

f. Un-zoom display
g. Change levels of entities
h. Fit entities to screen
i. Set various view ports
j. Refresh screen
k. Change views
l. Set active levels
m. Change entities between levels
m. Set screen center "pan"
n. Initialize display "clear"
o. Rotate display

G. Use analyze function
1. Use analyze function to interpret:
a. Point descriptions
b. Single entity information
c. Locations of entities
d. Distance between points
e. Area calculations
f. Calculation of angles

Practical Application:

For those of you that are using the Jonathan Lin book it is recommended that you complete the first 8 chapters of the book. Concern yourself with the CAD design for this module only.

It is also suggested that the Instructor interject some basic designs that they may get from local companies, this will give the students the experience of working on real drawings.

For those of you who will not be using the Lin book, most CAD/CAM software comes with a basic instruction book that may include basic designs. In addition, as stated above, the Instructor may add some basic drawings that would be used by local companies as an addition to the designs provided in the instructional books.

Evaluation and/or Verification:

A combination of written and hands-on testing should be used to establish the proficiency of the students.

For the written portion of the test a multiple choice test is recommended. Jonathan Lin's book has tests at the end of each chapter. These can be used as sample tests.

For the hands on testing, all students should create the same design and record their time. The time is then used to generate their grade for the hands on portion of the test. To tabulate a student's overall grade, written test time with the student's hands on test time are averaged.

Summary:

Review the main lesson points and answer students questions

Next Lesson Assignment:

MASTER Technical Module (MFG-G7) dealing with downloading programs via network.

MFG-G6-HO
Program CNC Machines Using a CAM System
Attachment 1: MASTER Handout

Objectives:

Upon completion of this unit the student will be able to:
1. Access CAD program options; and,
2. Create basic geometric entities.

Module Outline:

I. Access CAD Program Options
  A. Explain the configuration of CAD/CAM software
    1. Explain configuration of:
      a File and path names
      b. Installation, including DOS and Windows
      c. Configure software
      d. Interaction of files between each other
    2. Describe the "flow" process of CAD/CAM
  B. Access CAD software
    1. Access CAD software, including AutoCAD and CadKey, to:
      a. Create basic 2-dimensional designs
      b. Create 3-dimension designs
      c. Dimension designs to be used as drawings
      d. Create title blocks and borders for prints
      e. Print drawings
      f. Plot drawings
      g. Create general and local drawing notes and tolerances
    2. Describe various file conversion formats
    3. Import and export designs using conversions, including:
      a. IGES
      b. CADL
      c. DXF
      d. STL
  C. Access CAM software
    1. Load existing design
    2. Import and export design files from various file format standards, including:
      a. IGES
      b. DXF
      c. CADL
      d. STL
    3. Save design files to "permanent" memory

4. Access CAD section of CAM software to create
   a. Create basic 2-dimensional designs
   b. Create 3-dimension designs
   c. Dimension designs to be used as drawings
   d. Create title blocks and borders for prints
   e. Print drawings
   f. Plot drawings
   g. Create general and local drawing notes and tolerances

II. Create Basic Geometric Entities
   A. Create basic geometric entities, including:
      1. Points
      2. Fillets
      3. Lines
      4. Splines
      5. Arcs
      6. Chamfers
      7. Circles
      8. Letters including various machinable fonts
   B. Dimension completed designs to create detailed drawings
   C. Transform geometric entities using CAD commands
      1. Transform geometric entities, including:
         a. Mirror entities
         b. Rotate entities
         c. Scale complete entities using single scale option
         d. Translate using move and copy options
         e. Offset single and grouped geometric entities
         f. Use group function to effect multiple entities simultaneously
         g. Use result function to effect group movements
   D. Set menu selections to:
      1. View planes
      2. Construction planes
      3. Color choices
   E. Use Delete command:
      1. Use Delete commands, including:
         a. Chained and duplicate entities
         b. Exclusive entities (only)
         c. Inclusive entities (all)
         d. Enclosed in window
         e. Intersecting window
   F. Execute screen and display functions
      1. Use screen and display functions to:
         a. List screen statistics
         b. Display entity endpoints
         c. Clear group and result color designation

    - d. Change colors of entities
    - e. Display window
    - f. Un-zoom display
    - g. Change levels of entities
    - h. Fit entities to screen
    - i. Set various view ports
    - j. Refresh screen
    - k. Change views
    - l. Set active levels
    - m. Change entities between levels
    - m. Set screen center "pan"
    - n. Initialize display "clear"
    - o. Rotate display

G. Use analyze function

  1. Use analyze function to interpret:
    - a. Point descriptions
    - b. Single entity information
    - c. Locations of entities
    - d. Distance between points
    - e. Area calculations
    - f. Calculation of angles

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-G7

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-G7

Subject: **Manufacturing Technology** **Time 2 Hrs.**

Duty: **Perform Advanced Machining**
Task: Download Programs Via Network

Objective(s):

Upon completion of this unit the student will be able to:
a. Download programs from the network;
b. Upload programs to the network; and,
c. Perform edit and print functions via the network.

Instructional Materials:

MASTER Handout (MFG-G7-HO)
MASTER Laboratory Aid (MFG-G7-LA)

References:

Machine Tool Practices, Kibbe, Neely and Meyer, Wiley Publishers, Latest Edition
Instructor's Manual, Machine Tool Practices, Kibbe, Neely and Meyer, Wiley Publishers, Latest Edition
Student Workbook, Machine Tool Practices, Kibbe, Neely and Meyer, Wiley Publishers, Latest Edition

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-G1	"Prepare and Plan for CNC Machining Operations"
MFG-G4	"Operate CNC Machining Centers (Mills)"
MFG-G5	"Operate CNC Turning Centers (Lathes)"

Introduction:

Once the CNC program has been written, it must then be put into the CNC machine controller. Down through the years there have been many methods for accomplishing this task. Punched cards, paper/mylar tape, cassette tapes, disk drives and computer networks. The method which is quickly gaining in use is the use of a computer network to both download the program to the CNC machine control and perform other operations such as program edit and printing. This lesson briefly describes the use of a network for these file operations.

Presentation Outline:

I. Download Programs from the Network
  A. The CNC machine control and computer network must be properly connected (see Machine Operator's Manual)
  B. CNC programs must be copied into the proper file directory or folder
  C. Network software must be configured to "Send (download) Files" from file folder or directory to the machine controller
  C. CNC machine must be set to "Load Program"
  D. Verify that the program has been loaded into the CNC machine control unit and is available to run the machine

II. Upload Programs to the Network
  A. CNC machine control and computer network must be properly connected (see Machine Operator's Manual)
  B. Network software must be configured to "Receive (upload) Files" from machine controller to the network file folder or directory
  C. CNC machine must be set to "Send Program"
  D. Send program from machine control unit to network folder or directory
  D. Verify that the program has been copied into the network folder or directory

III. Perform Edit and Print Functions Via the Network

Practical Application:

Evaluation and/or Verification:

Due to the variances in programs, the instructor must prepare his own Self-Assessment.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-H1) dealing with understanding CAD/CAM programs.

MFG-G7-HO
Download Programs Via Network
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Download programs from the network;
- b. Upload programs to the network; and,
- c. Perform edit and print functions via the network.

Module Outline:

- I. Download Programs from the Network
  - A. The CNC machine control and computer network must be properly connected (see Machine Operator's Manual)
  - B. CNC programs must be copied into the proper file directory or folder
  - C. Network software must be configured to "Send (download) Files" from file folder or directory to the machine controller
  - C. CNC machine must be set to "Load Program"
  - D. Verify that the program has been loaded into the CNC machine control unit and is available to run the machine
- II. Upload Programs to the Network
  - A. CNC machine control and computer network must be properly connected (see Machine Operator's Manual)
  - B. Network software must be configured to "Receive (upload) Files" from machine controller to the network file folder or directory
  - C. CNC machine must be set to "Send Program"
  - D. Send program from machine control unit to network folder or directory
  - D. Verify that the program has been copied into the network folder or directory
- III. Perform Edit and Print Functions Via the Network

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
   a. No loose clothing, including ties;
   b. Long hair properly stowed;
   c. No jewelry;
   d. Hard, closed-toe shoes;
   e. Eye protection (safety glasses); and,
   f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MFG-H1

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-H1

Subject: **Manufacturing Technology** **Time: 3 Hrs.**

Duty: **Program Using CAM System**
Task: Understand CAD/CAM Programs

Objective(s):

Upon completion of this module the student will be able to:

a. Describe various CAD/CAM software;
b. Describe differences between CAD/CAM;
c. Discuss various software packages; and,
d. Describe various requirements for CAD/CAM software.

Instructional Materials:

MASTER Handout (MFG-H1-HO)

References:

There are many books available that discuss CAD/CAM, but most of them are very software company specific.

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1 through MFG-A7	"Practice Safety"
MFG-B1 through MFG-B15	"Apply Mathematical Concepts"
MFG-C1 through MFG-C10	"Interpret Engineering Drawings and Control Documents"
MFG-D1 through MFG-D6	"Recognize Different Manufacturing Materials and Processes"
MFG-E1 through MFG-E6	"Measure/Inspect"
MFG-F1 through MFG-F8	"Perform Conventional Machining"
MFG-G1 through MFG-G7	"Perform Advanced Machining"

Introduction:

This Module is designed to be an information module.

One of the most misunderstood computer applications is the area of CAD/CAM. The average individual has no idea what CAD/CAM even does. Many people who have a basic understanding of CAD/CAM automatically associate the term with creating drawings. Most people have no idea that the term CAD/CAM actually can cover a broad range of topics. It is important that before we venture into the area of CAD/CAM, we have an overall understanding of what some of the possibilities are.

The overall objective of this module is to allow the Instructor to present the possibilities of CAD/CAM to the students so that students will have a better understanding of the various applications of our field.

I have listed a few common software in the following outline only as a sampling of possible discussion areas.

Please be certain to include the information that this is only a small sampling of the overall available discussion topics.

Presentation Outline:

I. Demonstrate Understanding of CAD/CAM Programs
   A. Explain CAD/CAM programs
      1. Define Computer Aided Design (CAD)
      2. Define Computer Aided Manufacturing (CAM)
      3. Describe common applications of CAD and CAM
      4. Discuss common CAD packages to include:
         a. AutoCAD
         b. CadKey
         c. Micro Station
      5. Discuss Common CAM packages to include:
         a. MasterCam
         b. SurfCam
         c. SmartCam
      6. Describe common applications of CAD package design areas
         a. Architectural
         b. Electronics
         c. Mechanical
   B. Discuss various design modeling databases
      1. Wire Frame
      2. Surface Models
      3. Solid Models
II. Describe Various Abilities of CAD/CAM
   A. Discuss common applications of CAM software for:
      1. Vertical Machining applications
      2. Turning applications

        3. Grinding applications
        4. E.D.M. Applications
    B. Discuss benefits of using:
        1. Wire Frame
        2. Surface Models
        3. Solid Models
    C. Discuss flexibility and increased production for application of:
        1. CAD for Design
        2. CAM for Manufacturing
III. Describe Various Requirements for CAD/CAM Software
    A. Computer hardware
    B. Computer operating systems
    C. Education/Training

Practical Application:

After the Instructor has discussed what CAD/CAM is, it would be beneficial if the instructor could show some examples of the software in operation. A short demonstration of available software would give the students an overall example of what each software type "CAD" vs. "CAM" does.

After the demonstration, start a discussion with the group about applications they have seen, how they could apply CAD/CAM at their company, or how they could expand it's uses to benefit productivity.

Evaluation and/or Verification:

This module is written mainly for informational purposes.

If the Instructor feels a test is necessary, he could create a simple multiple choice test to cover the main points as it would apply to the group's needs.

Summary:

Review the main lesson points and answer student questions

Next Lesson Assignment:

MASTER Technical Module (MFG-H2) dealing with manipulation of CAD functions.

MFG-H1-HO
Understand CAD/CAM Programs
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this module the student will be able to:

- a. Describe various CAD/CAM software;
- b. Describe differences between CAD/CAM;
- c. Discuss various software packages; and,
- d. Describe various requirements for CAD/CAM software.

Module Outline:

- I. Demonstrate Understanding of CAD/CAM Programs
  - A. Explain CAD/CAM programs
    - 1. Define Computer Aided Design (CAD)
    - 2. Define Computer Aided Manufacturing (CAM)
    - 3. Describe common applications of CAD and CAM
    - 4. Discuss common CAD packages to include:
      - a. AutoCAD
      - b. CadKey
      - c. Micro Station
    - 5. Discuss Common CAM packages to include:
      - a. MasterCam
      - b. SurfCam
      - c. SmartCam
    - 6. Describe common applications of CAD package design areas
      - a. Architectural
      - b. Electronics
      - c. Mechanical
  - B. Discuss various design modeling databases
    - 1. Wire Frame
    - 2. Surface Models
    - 3. Solid Models
- II. Describe Various Abilities of CAD/CAM
  - A. Discuss common applications of CAM software for:
    - 1. Vertical Machining applications
    - 2. Turning applications
    - 3. Grinding applications
    - 4. E.D.M. Applications
  - B. Discuss benefits of using:
    - 1. Wire Frame
    - 2. Surface Models

        3. Solid Models
    C. Discuss flexibility and increased production for application of:
        1. · CAD for Design
        2. CAM for Manufacturing
III. Describe Various Requirements for CAD/CAM Software
    A. Computer hardware
    B. Computer operating systems
    C. Education/Training

MFG-H2

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-H2

Subject: **Manufacturing Technology** **Time: 30-50 Hrs.**

Duty: **Program Using CAM System**
Task: Manipulate CAD Functions

Objective(s):

Upon completion of this module the student will be able to:

a. Demonstrate the correct use of CAD/CAM software to generate basic 2-dimensional shapes; and,
b. Demonstrate the correct use of CAD/CAM software to generate basic 3-dimensional shapes.

Instructional Materials:

MASTER Handout (MFG-H2-HO)

References:

There are not many books available that discuss CAD/CAM with an emphasis on CAM, but normally there is an instructional manual that comes with the purchase of the software packages.

In the area of CAD there are many after market books available. Please check to see what is available for your software.

If you are using either MasterCam or SurfCam, there is now an aftermarket book for each. To get more information about these books contact:

Dr. Su-Chen Jonathan Lin
Scholars International Publishing Corporation
2675 Georgetown Blvd.
Ann Arbor, MI. 48105
Telephone: (313) 930-0813
Fax. Number: (313) 741-1927

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1 through MFG-A7 "Practice Safety"
MFG-B1 through MFG-B15 "Apply Mathematical Concepts"

MFG-C1 through MFG-C10	"Interpret Engineering Drawings and Control Documents"
MFG-D1 through MFG-D6	"Recognize Different Manufacturing Materials and Processes"
MFG-E1 through MFG-E6	"Measure/Inspect"
MFG-F1 through MFG-F8	"Perform Conventional Machining"
MFG-G1 through MFG-G7	"Perform Advanced Machining"
MFG-H1	"Understand CAD/CAM Programs"

Introduction:

Part I:

In this module we will discuss the actual use of CAD/CAM software to create electronic images. For those students who are using MasterCam you will notice that the information listed in the outline below relates directly to the menu commands in MasterCam.

For those of you who are not using MasterCam, your software will have menu selections that, although they are not the exactly the same as the ones listed in the outline below, they will have similar commands to perform the same type operations.

Also for anyone using either MasterCam or SurfCam, I would recommend the book listed in the resource section of this outline written by Dr. Jonathan Lin.

For those of you who are using some other company's software, there should be some type of written information that will allow you to become familiar with the basic operations listed below.

Part II:

There is no doubt that in the long term CAD/CAM saves a tremendous amount of time, and is much more flexible than paper drawings. Having made this statement it is important to note that the process of using CAD/CAM software to generate designs is a process that can be very time consuming. There is no automatic design creation that I am aware of as of this writing. Using computers to create designs is like everything else: it takes practice to become good at it.

The outline listed below covers the basic geometric elements used in creating designs. This outline only discusses wire frame geometry creation; it does not discuss either surface modeling or solid modeling. Wire frame design, although not as sophisticated as surfaces and solid modeling, encompasses the building blocks that will be used later on in more advanced CAD designs.

In CNC/CAM, we are interested in CAD as a method of generating the necessary geometric entities that will allow us to guide a cutting tool along a defined boundary or a set of boundaries to create the necessary information that will control the actions of a CNC machine tool to create a machined part to given specifications.

When we have completed the CAD component, we are only getting started. We then have to complete the CAM component as required to move onto the CNC machine.

In the overall process of CAD/CAM/CNC, the CAD section can often consume a vast majority of the time used in completion of a manufactured object. The ability to create a quality design in a short amount of time is definitely an important part of the complete process.

Presentation Outline:

- I. Access CAD Program Options
  - A. Explain the configuration of CAD/CAM software
    - 1. Explain configuration of:
      - a File and path names
      - b. Installation, including DOS and Windows
      - c. Configure software
      - d. Interaction of files between each other
    - 2. Describe the "flow" process of CAD/CAM
  - B. Access CAD software
    - 1. Access CAD software, including AutoCAD and CadKey, to:
      - a. Create basic 2-dimensional designs
      - b. Create 3-dimension designs
      - c. Dimension designs to be used as drawings
      - d. Create title blocks and borders for prints
      - e. Print drawings
      - f. Plot drawings
      - g. Create general and local drawing notes and tolerances
    - 2. Describe various file conversion formats
    - 3. Import and export designs using conversions, including:
      - a. IGES
      - b. CADL
      - c. DXF
      - d. STL
  - C. Access CAM software
    - 1. Load existing design
    - 2. Import and export design files from various file format standards, including:
      - a. IGES
      - b. DXF

        - c. CADL
        - d. STL
    - 3. Save design files to "permanent" memory
    - 4. Access CAD section of CAM software to create
        - a. Create basic 2-dimensional designs
        - b. Create 3-dimension designs
        - c. Dimension designs to be used as drawings
        - d. Create title blocks and borders for prints
        - e. Print drawings
        - f. Plot drawings
        - g. Create general and local drawing notes and tolerances
- II. Create Basic Geometric Entities
    - A. Create basic geometric entities, including:
        - 1. Points
        - 2. Fillets
        - 3. Lines
        - 4. Splines
        - 5. Arcs
        - 6. Chamfers
        - 7. Circles
        - 8. Letters including various machinable fonts
    - B. Dimension completed designs to create detailed drawings
    - C. Transform geometric entities using CAD commands
        - 1. Transform geometric entities, including:
            - a. Mirror entities
            - b. Rotate entities
            - c. Scale complete entities using single scale option
            - d. Translate using move and copy options
            - e. Offset single and grouped geometric entities
            - f. Use group function to effect multiple entities simultaneously
            - g. Use result function to effect group movements
    - D. Set menu selections to:
        - 1. View planes
        - 2. Construction planes
        - 3. Color choices
    - E. Use Delete command:
        - 1. Use Delete commands, including:
            - a. Chained and duplicate entities
            - b. Exclusive entities (only)
            - c. Inclusive entities (all)
            - d. Enclosed in window
            - e. Intersecting window
    - F. Execute screen and display functions
        - 1. Use screen and display functions to:

        a. List screen statistics
        b. Display entity endpoints
        c. Clear group and result color designation
        d. Change colors of entities
        e. Display window
        f. Un-zoom display
        g. Change levels of entities
        h. Fit entities to screen
        i. Set various view ports
        j. Refresh screen
        k. Change views
        l. Set active levels
        m. Change entities between levels
        m. Set screen center "pan"
        n. Initialize display "clear"
        o. Rotate display

G. Use analyze function
    1. Use analyze function to interpret:
        a. Point descriptions
        b. Single entity information
        c. Locations of entities
        d. Distance between points
        e. Area calculations
        f. Calculation of angles

Practical Application:

For those of you that are using the Jonathan Lin book it is recommended that you complete the first 8 chapters of the book. Concern yourself with the CAD design for this module only.

It is also suggested that the Instructor interject some basic designs that they may get from local companies, this will give the students the experience of working on real drawings.

For those of you who will not be using the Lin book, most CAD/CAM software comes with a basic instruction book that may include basic designs. In addition, as stated above, the Instructor may add some basic drawings that would be used by local companies as an addition to the designs provided in the instructional books.

Evaluation and/or Verification:

A combination of written and hands-on testing should be used to establish the proficiency of the students.

For the written portion of the test a multiple choice test is recommended. Jonathan Lin's book has tests at the end of each chapter. These can be used as sample tests.

For the hands on testing, all students should create the same design and record their time. The time is then used to generate their grade for the hands on portion of the test. To tabulate a student's overall grade, written test time with the student's hands on test time are averaged.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-H3) dealing with processing simple tool-path data.

MFG-H2-HO
Manipulate CAD Functions
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this module the student will be able to:

a. Demonstrate the correct use of CAD/CAM software to generate basic 2-dimensional shapes; and,

b. Demonstrate the correct use of CAD/CAM software to generate basic 3-dimensional shapes.

Module Outline:

I. Access CAD Program Options
  A. Explain the configuration of CAD/CAM software
    1. Explain configuration of:
      a File and path names
      b. Installation, including DOS and Windows
      c. Configure software
      d. Interaction of files between each other
    2. Describe the "flow" process of CAD/CAM
  B. Access CAD software
    1. Access CAD software, including AutoCAD and CadKey, to:
      a. Create basic 2-dimensional designs
      b. Create 3-dimension designs
      c. Dimension designs to be used as drawings
      d. Create title blocks and borders for prints
      e. Print drawings
      f. Plot drawings
      g. Create general and local drawing notes and tolerances
    2. Describe various file conversion formats
    3. Import and export designs using conversions, including:
      a. IGES
      b. CADL
      c. DXF
      d. STL
  C. Access CAM software
    1. Load existing design
    2. Import and export design files from various file format standards, including:
      a. IGES
      b. DXF
      c. CADL

        - d. STL
    - 3. Save design files to "permanent" memory
    - 4. Access CAD section of CAM software to create
        - a. Create basic 2-dimensional designs
        - b. Create 3-dimension designs
        - c. Dimension designs to be used as drawings
        - d. Create title blocks and borders for prints
        - e. Print drawings
        - f. Plot drawings
        - g. Create general and local drawing notes and tolerances

II. Create Basic Geometric Entities
- A. Create basic geometric entities, including:
    - 1. Points
    - 2. Fillets
    - 3. Lines
    - 4. Splines
    - 5. Arcs
    - 6. Chamfers
    - 7. Circles
    - 8. Letters including various machinable fonts
- B. Dimension completed designs to create detailed drawings
- C. Transform geometric entities using CAD commands
    - 1. Transform geometric entities, including:
        - a. Mirror entities
        - b. Rotate entities
        - c. Scale complete entities using single scale option
        - d. Translate using move and copy options
        - e. Offset single and grouped geometric entities
        - f. Use group function to effect multiple entities simultaneously
        - g. Use result function to effect group movements
- D. Set menu selections to:
    - 1. View planes
    - 2. Construction planes
    - 3. Color choices
- E. Use Delete command:
    - 1. Use Delete commands, including:
        - a. Chained and duplicate entities
        - b. Exclusive entities (only)
        - c. Inclusive entities (all)
        - d. Enclosed in window
        - e. Intersecting window
- F. Execute screen and display functions
    - 1. Use screen and display functions to:
        - a. List screen statistics

- b. Display entity endpoints
- c. Clear group and result color designation
- d. Change colors of entities
- e. Display window
- f. Un-zoom display
- g. Change levels of entities
- h. Fit entities to screen
- i. Set various view ports
- j. Refresh screen
- k. Change views
- l. Set active levels
- m. Change entities between levels
- m. Set screen center "pan"
- n. Initialize display "clear"
- o. Rotate display

G. Use analyze function

- 1. Use analyze function to interpret:
  - a. Point descriptions
  - b. Single entity information
  - c. Locations of entities
  - d. Distance between points
  - e. Area calculations
  - f. Calculation of angles

MFG-H3

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-H3

Subject:	**Manufacturing Technology**	**Time: 20-30 Hrs.**
Duty:	**Program Using CAM System**	
Task:	Process Simple Toolpath Data	

Objective(s):

Upon completion of this module the student will be able to:

a. Properly identify various parts of CNC program generation;
b. Demonstrate the use of the post-processor and co-processor for intermediate CNC data;
c. Perform editing of CNC programs using various software; and
d. Perform verification of completed toolpaths.

Instructional Materials:

MASTER Handout (MFG-H3-HO)

References:

There are not many books available that discuss CAD/CAM with an emphasis on CAM, but normally there is an instructional manual that comes with the purchase of the software packages.

In the area of CAD there are many after market books available. Please check to see what is available for your software.

If you are using either MasterCam or SurfCam, there is now an aftermarket book for each. To get more information about these books contact:

Dr. Su-Chen Jonathan Lin
Scholars International Publishing Corporation
2675 Georgetown Blvd.
Ann Arbor, MI. 48105
Telephone: (313) 930-0813
Fax. Number: (313) 741-1927

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1 through MFG-A7 "Practice Safety"

MFG-B1 through MFG-B15	"Apply Mathematical Concepts"
MFG-C1 through MFG-C10	"Interpret Engineering Drawings and Control Documents"
MFG-D1 through MFG-D6	"Recognize Different Manufacturing Materials and Processes"
MFG-E1 through MFG-E6	"Measure/Inspect"
MFG-F1 through MFG-F8	"Perform Conventional Machining"
MFG-G1 through MFG-G7	"Perform Advanced Machining"
MFG-H1	"Understand CAD/CAM Programs"
MFG-H2	"Manipulate CAD Functions"

Introduction:

Computer Aided Manufacturing (CAM) software has changed the way in which we generate CNC code more dramatically then any previous invention since the pocket calculator.

In the past we have had to generate programs using a tedious character by character process. With the advent of CAM software, which uses a graphic interface, we are free to be much more creative in both design and manufacturing of machined objects.

One benefit of CAM software is that it's use has removed much of the need of the technician to continually perform both simple and advanced mathematical equations. It is very easy to use these software to generate code to machine objects that would not be possible to create without the assistance of the computer and CAD/CAM software applications.

The proper use of CAM has allowed a much larger group of people to work in the field of creating CNC programs to "drive" various machine tools.

It is important to note that learning how to use a CAM package does not make the user a machinist, nor does the software know how to machine any objects. It is a tremendous benefit to all if the operator of the CAD/CAM software has a good understanding of general machining to include CNC.

Presentation Outline:

I. Generate Numerical (NC) Code
    A. Generate NC code to access:
        1. Turning center "lathe".
        2. Vertical machining center "mill"
II. Generate Basic Vertical Machining Code
    A. Generate basic vertical machining code for operations, including:
        1. Outside and inside contours

        2. Pocketing operations
            a. Islands
            b. Multiple "Z" level islands
        3. Drilling, reaming, spot drilling, tapping operations

III. Program Lathe or Turning Operations
    A. Use CAD section to create geometric designs
    B. Create lathe tools as required
    C. Create toolpath information to rough and finish
        1. Create toolpath information to rough and finish during:
            a. Turning operations
            b. Facing operations
            c. Grooving operations
            d. Internal boring operations / external boring operations
            e. Internal and external threading
    D. Edit toolpath data files
        1. View and edit tool path data files, including:
            a. Display centerline tool path
            b. Calculate time to machine .
            c. Filter tool path data to reduce size and time
            d. Change feed rates and compare results
            e. Edit tool path data to change possible variables
            f. Define tool selections and operating parameters
            g. Define materials to be machined
            h. Create set-up document
        2. Verify toolpaths by cutting part as solid model
        3. Verify toolpaths by "backplotting" toolpaths
    E. Process Tool Path Data to Numerical Control Code
        1. Select post processing file relative to machine tool being used
        2. Execute post processing function
        3. Edit numerical control program if needed
    F. Describe and Execute Post-Processor or Co-processor Functions
        1. Describe post-processor and co-processor functions
        2. Run processors

Practical Application:

For those of you that are using the Jonathan Lin book I would recommend completing the first 8 chapters of the book to generate the CAD sections. Then complete the toolpaths for those designs. In the back section of the book there is a lathe section to be used to get a better understanding of the lathe section of the CAM software.

Please make sure to take your time and get a very good understanding of how the basic toolpath commands work. This will not only help you later in the surface modules, but you will more than likely have to use these commands as a large portion of your responsibilities.

Please do not skip over the pockets, contours, and drilling operations so you can advance to the more advanced modules. Approximately 85% of all machined pieces fall into this category.

It is suggested that the Instructor interject some basic designs that they may get from local companies. This will give the students the experience of working on real designs.

For those of you who will not be using the Lin book, most CAD/CAM software comes with a basic instruction book that may include basic designs. In addition, as stated above, add some basic drawings that would be used by local companies as an addition to the designs provided in the instructional books.

Evaluation and/or Verification:

Use a combination of written and hands on tests to establish the proficiency of the students. For the written portion of the test, create a multiple choice test. Jonathan Lin's book has tests at the end of each chapter. These can be used as sample tests.

For the hands on testing, have all the students create the same design and create the required toolpaths needed to machine the associated objects. Also have them machine the parts as a solid model in the verification section of the software. Record all the students' time for the various sections.

Use the time to generate their grade for the hands on portion of the test. To tabulate their overall grade, average their written test time with their hands on test time.

Summary:

Review the main lesson points and answer student questions

Next Lesson Assignment:

MASTER Technical Module (MFG-H4) dealing with creating advanced surface models.

MFG-H3-HO
Process Simple Toolpath Data
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to:

- a. Properly identify various parts of CNC program generation;
- b. Demonstrate the use of the post-processor and co-processor for intermediate CNC data;
- c. Perform editing of CNC programs using various software; and
- d. Perform verification of completed toolpaths.

Module Outline:

- I. Generate Numerical (NC) Code
  - A. Generate NC code to access:
    - 1. Turning center "lathe"
    - 2. Vertical machining center "mill"
- II. Generate Basic Vertical Machining Code
  - A. Generate basic vertical machining code for operations, including:
    - 1. Outside and inside contours
    - 2. Pocketing operations
      - a. Islands
      - b. Multiple "Z" level islands
    - 3. Drilling, reaming, spot drilling, tapping operations
- III. Program Lathe or Turning Operations
  - A. Use CAD section to create geometric designs
  - B. Create lathe tools as required
  - C. Create toolpath information to rough and finish
    - 1. Create toolpath information to rough and finish during:
      - a. Turning operations
      - b. Facing operations
      - c. Grooving operations
      - d. Internal boring operations / external boring operations
      - e. Internal and external threading
  - D. Edit toolpath data files
    - 1. View and edit tool path data files, including:
      - a. Display centerline tool path
      - b. Calculate time to machine
      - c. Filter tool path data to reduce size and time
      - d. Change feed rates and compare results
      - e. Edit tool path data to change possible variables
      - f. Define tool selections and operating parameters

            g. Define materials to be machined
            h. Create set-up document
        2. Verify toolpaths by cutting part as solid model
        3. Verify toolpaths by "backplotting" toolpaths
    E. Process Tool Path Data to Numerical Control Code
        1. Select post processing file relative to machine tool being used
        2. Execute post processing function
        3. Edit numerical control program if needed
    F. Describe and Execute Post-Processor or Co-processor Functions
        1. Describe post-processor and co-processor functions
        2. Run processors

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-H4

Subject: **Manufacturing Technology** **Time: 30-50 Hrs.**

Duty: **Program Using CAM System**
Task: Create Advanced Surface Models

Objective(s):

Upon completion of this module the student will be able to demonstrate the correct use of CAD/CAM software to create 2- and 3-dimensional geometric shapes and surface models.

Instructional Materials:

MASTER Handout (MFG-H4-HO)

References:

As stated in earlier modules, there are unfortunately not many books available that discuss CAD/CAM with an emphasis on CAM. Normally there is an instructional manual that comes with the purchase of the software packages.

If you are using either MasterCam or SurfCam, there is now an aftermarket book for each. To get more information about these books contact:

Dr. Su-Chen Jonathan Lin
Scholars International Publishing Corporation
2675 Georgetown Blvd.
Ann Arbor, MI. 48105
Telephone: (313) 930-0813
Fax. Number: (313) 741-1927

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1 through MFG-A7	"Practice Safety"
MFG-B1 through MFG-B15	"Apply Mathematical Concepts"
MFG-C1 through MFG-C10	"Interpret Engineering Drawings and Control Documents"
MFG-D1 through MFG-D6	"Recognize Different Manufacturing Materials and Processes"
MFG-E1 through MFG-E6	"Measure/Inspect"

MFG-F1 through MFG-F8	"Perform Conventional Machining"
MFG-G1 through MFG-G7	"Perform Advanced Machining"
MFG-H1	"Understand CAD/CAM Programs"
MFG-H2	"Manipulate CAD Functions"
MFG-H3	"Process Simple Toolpath Data"

Introduction:

Part I:

This module is written with an emphasis on the software called MasterCam, which is created by the company ,C.N.C. Software Inc., version 6.12. As many of us know, software as well as our technology, changes very rapidly. By the time you review this module, much of the nomenclature may have changed. Please check your version number to see what changes have been made.

Some of the surface names used with the software SurfCam, which is created by the company SurfCam, Inc., are included in italics in the presentation outline. As with MasterCam, the names of these surface entities may have changed by the time you read this.

Please note that we are not trying to misrepresent any of the software. If you have any specific questions please contact the specific software manufacture.

This module can be looked at as an extension to the previous CAD/CAM module, which emphasizes CAD.

Part II:

As we have seen in the previous CAD module, the proper application of CAD/CAM software allows us a tremendous amount of flexibility in our designs. As we look at more sophisticated designs, we find that defining the wireframe or "outline" no longer gives us the amount of information needed to describe our design properly. Examples that would create a need for surface modeling are very easily seen in the mold making industry. It is important to note that even though this industry is not as large as the general CAD marketplace, this area is where the higher rates of pay are found.

As we create designs using surface models, we can truly start to appreciate the power of the computer used in conjunction with CAD/CAM software. It is important to remember that we are creating these designs so we will be able to generate advanced toolpaths for the CNC machines.

Presentation Outline:

- I. Create Advanced Designs with CAD Section of CAD/CAM Program
  - A. Create advanced geometric surfaces
    - 1. Create advanced geometric surfaces to include:
      - a. Lofted / *Cross Section*
      - b. Blend
      - c. Swept / *Drive Curve*
      - d. Trim
      - e. Coons / *4-Curve*
      - f. Draft
      - g. Offset
      - h. Nurb Surface
      - i. Fillet
      - j. Parametric Surface
  - B. Edit geometric entities
    - 1. Modify and edit advanced geometric surfaces to include:
      - a. Trimming
      - b. Breaking
      - c. Joining
      - d. Fillet
  - C. Edit advanced geometric surfaces
    - 1. Modify and edit advanced geometric surfaces to include:
      - a. Control points of nurbs
      - b. Conversion to nurbs entity
      - c. Extend entities
      - d. Drag entities
      - e. Edit entities
    - 2. Change cutter offset side
    - 3. Change cutting directions
    - 4. Turn surface normal arrows on and off
    - 5. Decompose composite surfaces
    - 6. Twist vectors of parametric surface
    - 7. Create polygons on surface
    - 8. Align surface normals
    - 9. Trim surfaces
    - 10. Untrim trimmed surfaces
  - D. Transform geometric entities using CAD commands
    - 1. Scale X, Y, and Z at possible separate ratios
  - E. Execute screen and display functions
    - 1. Use screen and display functions to:
      - a. Change surface density
      - b. Shade surface models
      - c. Blank and unblank entities

Practical Application:

For those of you that are using the Jonathan Lin book I would recommend completing the chapters of the book that deal with the generation of surface models.

It is suggested that the Instructor interject some designs that they may get from local companies. This will give the students the experience of working on real designs. Some of the designs that make good examples for the use of surface modeling are found in the mold making industry.

For those of you who will not be using the Lin book, most CAD/CAM software comes with a basic instruction book that may include surface models.

Evaluation and/or Verification :

Use a combination of written and hands on testing to establish the proficiency of the students.

For the written portion of the test, create a multiple choice test. Jonathan Lin's book has tests at the end of each chapter. These can be used as sample tests.

For the hands on testing, have all the students create the same design and record their time. Use the time to generate their grade for the hands on portion of the test. To tabulate their overall grade, average their written test time with their hands on test time.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-H5) dealing with processing complex toolpath functions.

MFG-H4-HO
Create Advanced Surface Models
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to demonstrate the correct use of CAD/CAM software to create 2- and 3-dimensional geometric shapes and surface models.

Module Outline:

I. Create Advanced Designs with CAD Section of CAD/CAM Program
  A. Create advanced geometric surfaces
    1. Create advanced geometric surfaces to include:
      a. Lofted / *Cross Section*
      b. Blend
      c. Swept / *Drive Curve*
      d. Trim
      e. Coons / *4-Curve*
      f. Draft
      g. Offset
      h. Nurb Surface
      i. Fillet
      j. Parametric Surface
  B. Edit geometric entities
    1. Modify and edit advanced geometric surfaces to include:
      a. Trimming
      b. Breaking
      c. Joining
      d. Fillet
  C. Edit advanced geometric surfaces
    1. Modify and edit advanced geometric surfaces to include:
      a. Control points of nurbs
      b. Conversion to nurbs entity
      c. Extend entities
      d. Drag entities
      e. Edit entities
    2. Change cutter offset side
    3. Change cutting directions
    4. Turn surface normal arrows on and off
    5. Decompose composite surfaces
    6. Twist vectors of parametric surface
    7. Create polygons on surface

        8. Align surface normals
        9. Trim surfaces
        10. Untrim trimmed surfaces
    D. Transform geometric entities using CAD commands
        1. Scale X, Y, and Z at possible separate ratios
    E. Execute screen and display functions
        1. Use screen and display functions to:
            a. Change surface density
            b. Shade surface models
            c. Blank and unblank entities

MFG-H5

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-H5

Subject: **Manufacturing Technology** **Time: 35-50 Hrs.**

Duty: **Program Using CAM System**
Task: Process Complex Toolpath Functions

Objective(s):

Upon completion of this module the student will be able to:

1. Demonstrate an understanding of the use of single surface machining;
2. Demonstrate an understanding of the use of multiple surface machining;
3. Demonstrate an understanding of the use of multiple tool planes and multi-axis machining; and,
4. Digitize existing objects to create new toolpaths.

Instructional Materials:

MASTER Handout (MFG-H5-HO)

References:

As stated in earlier modules, there are unfortunately not many books available that discuss CAD/CAM with an emphasis on CAM. Normally there is an instructional manual that comes with the purchase of the software packages.

If you are using either MasterCam or SurfCam, there is now an aftermarket book for each. To receive more information about these books contact:

Dr. Su-Chen Jonathan Lin
Scholars International Publishing Corporation
2675 Georgetown Blvd.
Ann Arbor, MI. 48105
Telephone: (313) 930-0813
Fax. Number: (313) 741-1927

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1 through MFG-A7	"Practice Safety"
MFG-B1 through MFG-B15	"Apply Mathematical Concepts"

MFG-C1 through MFG-C10	"Interpret Engineering Drawings and Control Documents"
MFG-D1 through MFG-D6	"Recognize Different Manufacturing Materials and Processes"
MFG-E1 through MFG-E6	"Measure/Inspect"
MFG-F1 through MFG-F8	"Perform Conventional Machining"
MFG-G1 through MFG-G7	"Perform Advanced Machining"
MFG-H1	"Understand CAD/CAM Programs"
MFG-H2	"Manipulate CAD Functions"
MFG-H3	"Process Simple Toolpath Data"
MFG-H4	"Create Advanced Surface Models"

Introduction:

Part I:

This module is not written with an emphasis on any specific software. I am more familiar with the software package, MasterCam, which is created by the company, C.N.C. Software Inc., version 6.12. As many of us know, software as well as our technology, changes very rapidly. By the time you review this module, much of the nomenclature may have changed. Please check your version number to see what changes have been made.

Both MasterCam and SurfCam, created by Surfware, Inc., are CAD/CAM software which is used for both CAD and CAM.

Please note that we are not trying to misrepresent any of the software. If you have any specific questions, please contact the software manufacture for more information.

This module can be looked at as an extension to the previous CAD/CAM module which emphasizes basic CAM.

Most software will have similar type operations. They may call the operations different names but more then likely they will accomplish the same type operations.

Part II:

As we have seen in the previous CAM module, the proper application of CAD/CAM software allows us a tremendous amount of flexibility in our designs as well as toolpaths. As we looked at more sophisticated designs, we found that defining the wireframe or "outline" no longer gave us the amount of information needed to describe our design properly. Examples that would create a need for surface machining are very easily seen in the mold making industry. It is important to note that even though this industry is not as large as the general CAM marketplace, this area is where the higher rates of pay are found.

As we create designs using surface models, we could truly start to appreciate the power of the computer used in conjunction with CAD/CAM software. It is important to remember that we created these designs so we could generate advanced toolpaths for the CNC machines.

As with the CAD modeling, in the earlier module (I4), we created toolpaths using wire frame designs. In this section we will work on surface machining which, as of this writing, is one of the most advanced methods of generating complex toolpaths.

Many of the toolpaths that we can create using surfacing cannot be created without the use of the computer coupled with CAD/CAM software. Those toolpaths that could be created without the use of CAD/CAM would take a tremendous amount of time and energy.

The use of CAD/CAM and surface toolpaths has allowed a much larger section of the population to accomplish, in a very short time period, the creation of programs that they would not be able to consider otherwise.

Many companies have been able to increase their level of technology to include the design and manufacturing of sophisticated shapes that the "wireframe" models would not be able to achieve.

As I have stated in the CAD module that covers surfacing, this marketplace is not as large as the "wireframe" marketplace but it is much more specialized. It pays higher wage rates to those who can use the technology, and is very challenging.

Presentation Outline:

I. Process Tool Path Data
    A. Generate advanced vertical machining code
        1. Generate code for three axis surface machining to include:
            a. Single surface machining,
                1) Create roughing toolpaths
                2) Create finishing toolpaths
            b. Multiple surface machining
                1) Create roughing toolpaths
                2) Create finishing toolpaths
        2. Generate code for four and five-axis surface machining to include:
            a. Single surface machining
                1) Create roughing toolpaths

    - 2) Create finishing toolpaths
  - b. Multiple surface machining
    - 1) Create roughing toolpaths
    - 2) Create finishing toolpaths
- B. Import and machine scanned data
  - 1. Import and machine three-dimensional data
    - a. Collect data points using C.M.M.
    - b. Collect data using vertical machining center and digitizing probe
    - c. Convert scanned data into usable geometric entities
    - d. Create appropriate surface types from wireframes
    - e. Generate numerical control programs using surface models
- C. Verify toolpaths
  - 1. Verify multi-surface toolpaths
  - 2. Verify 4th and 5th axis machine code
- D. Describe and execute post-processor or co-processor functions
  - 1. Edit processors for 4th and 5th axis machining
  - 2. Process intermediate files into NC code

Practical Application:

For those of you that are using the Jonathan Lin book I would recommend completing the chapters of the book that deal with the generation of surface models toolpaths.

It is suggested that the Instructor interject some designs that they may get from local companies. This will give the students the experience of working on real designs. Some of the designs that make good examples for the use of surface modeling are found in the mold making industry.

The digitizing experiments, although not an actual part of the CAD/CAM software applications, allow us to capture data using a very non-traditional method. This data allows us to create surface models, and then toolpaths from existing actual objects. These experiments can only be accomplished if the user has access to the necessary equipment to capture the data needed.

Evaluation and/or Verification:

Use a combination of written and hands on tests to establish the proficiency of the students.

For the written portion of the test, create a multiple choice test. Jonathan Lin's book has tests at the end of each chapter. These can be used as sample tests.

For the hands on testing, have all the students create the same design and create the required toolpaths needed to machine the associated objects. You may also have them machine the parts as a solid model in the verification section of the software. Use the time to generate their grade for the hands on a portion of the test. To tabulate their overall grade, average their written test time with their hands on test time.

Summary:

Review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-I1) dealing with using computer operating systems.

MFG-H5-HO
Process Complex Toolpath Functions
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to:

1. Demonstrate an understanding of the use of single surface machining;
2. Demonstrate an understanding of the use of multiple surface machining;
3. Demonstrate an understanding of the use of multiple tool planes and multi-axis machining; and,
4. Digitize existing objects to create new toolpaths.

Module Outline:

I. Process Tool Path Data
  A. Generate advanced vertical machining code
    1. Generate code for three axis surface machining to include:
      a. Single surface machining,
        1) Create roughing toolpaths
        2) Create finishing toolpaths
      b. Multiple surface machining
        1) Create roughing toolpaths
        2) Create finishing toolpaths
    2. Generate code for four and five-axis surface machining to include:
      a. Single surface machining
        1) Create roughing toolpaths
        2) Create finishing toolpaths
      b. Multiple surface machining
        1) Create roughing toolpaths
        2) Create finishing toolpaths
  B. Import and machine scanned data
    1. Import and machine three-dimensional data
      a. Collect data points using C.M.M.
      b. Collect data using vertical machining center and digitizing probe
      c. Convert scanned data into usable geometric entities
      d. Create appropriate surface types from wireframes
      e. Generate numerical control programs using surface models
  C. Verify toolpaths
    1. Verify multi-surface toolpaths

        2. Verify 4th and 5th axis machine code

D. Describe and execute post-processor or co-processor functions
    1. Edit processors for 4th and 5th axis machining
    2. Process intermediate files into NC code

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

Duties	Tasks												
A Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
	B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

Duty I

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-I1

Subject: **Manufacturing Technology** **Time: 12 Hrs.**

Duty: **Use Computers**
Task: Use Computer Operating Systems

Objective(s):

Upon completion of this module the student will be able to:

a. Distinguish between a directory/file folder and a file;
b. Understand data organization and terminology;
c. Explain the function of an operating system;
d. Explain what the term "IBM compatible" means;
e. Use a mouse;
f. Utilize file manager in Windows 3.1 to view directories and files;
g. Utilize explorer in Windows 95 to view folders and files; and,
h. Explain and use basic network concepts.

Instructional Materials:

Data Disks with files
MASTER Handout (MFG-I1-HO)
MASTER Laboratory Worksheets (MFG-I1-LW1; MFG-I1-LW2; MFG-I1-LW3)
MASTER Self-Assessment

References:

Windows 3.1 and/or *Windows 95 Computer Lab*, Latest Edition
Introduction to Using Windows 3.1, Latest Edition
Introduction to Using Windows 95, Latest Edition
Introduction to Using Networks, Latest Edition

Student Preparation:

None

Introduction:

Machinists are like all other people in today's workplace. They must be able to use the computer as a tool to get their work done. In order to use computers effectively, it is important that one understands components and operating systems as they relate to the use of a computer. This module will introduce the student to these concepts and provide a foundation for developing good basic skills in the use of a computer.

Presentation Outline:

- I. Introduction to Computers
  - A. Discuss hardware components
  - B. Explain disk drive configurations
  - C. Discuss software
    - 1. Application programs
    - 2. Operating systems
      - a. DOS
      - b. Windows
      - c. Windows 95
      - d. Network operating systems
  - D. Discuss brands of computers
    - 1. Apple & MacIntosh
    - 2. IBM & compatibles
  - E. Explain data organization
    - 1. Files
    - 2. Filenames and extensions
    - 3. Root directory & backward slash (\)
    - 4. Directory and subdirectory structure
  - F. Explain the terms directory path and file specification
- II. Introduction to the Windows Operating System
  - A. Discuss how to start Windows
  - B. Discuss basic mouse operations
    - 1. Pointing
    - 2. Clicking
    - 3. Double clicking
    - 4. Dragging
  - C. Discuss Windows elements
    - 1. Window borders
    - 2. Title bar
    - 3. Control-menu box
    - 4. Mouse pointer
    - 5. Sizing buttons
    - 6. Scroll bar and arrows
    - 7. Menu bar
    - 8. Pull-down menus
    - 9. Work area
    - 10. Icons
  - D. Use File Manager

        - 1. Explain the file manager screen
        - 2. Change drives
        - 3. Expand directories
        - 4. Collapse directories
        - 5. Change file information displayed
        - 6. Run an application
    - E. Run an application from an icon in Program Manager
- III. Introduction to Windows 95 Operating System
    - A. Discuss Windows 95 desktop components
        - 1. My Computer icon
        - 2. Recycle Bin icon
        - 3. Network Neighborhood icon
        - 4. Start button
        - 5. Taskbar
    - B. Use Windows 95
        - 1. Open a window from an icon
        - 2. Use sizing buttons and close button
        - 3. Discuss Start menu
        - 4. Open an application using the Start button
        - 5. Explain shut down menu under Start
        - 6. Use Windows Explorer
            - a. Explain Windows Explorer toolbar buttons
            - b. Explain folders and subfolders
            - c. Select folders
            - d. Open and close folders
            - e. Change drives
            - f. Change file list display
- IV. Introduction to Computer Network Systems
    - A. Explain what a network is
    - B. Discuss basic network components
        - 1. File server
        - 2. Network operating system (NOS)
        - 3. Local area network (LAN) cable
        - 4. Network devices
    - C. Explain types of networks
        - 1. Campus
        - 2. National
        - 3. International
    - D. Explain and use basic network concepts
        - 1. File server login/logout
        - 2. Application sharing
        - 3. Document sharing
        - 4. Electronic mail

Practical Application:

Students will use Windows 3.1, Windows 95, and a NOS by completing the Laboratory Worksheets labeled MFG-I1-LW1, MFG-I1-LW2, and MFG-I1-LW3.

Evaluation and/or Verification:

Successful completion of this technical module will be determined by the student's ability to successfully demonstrate the following competencies:

1. Explain the function of an operating system;
2. Define terminology associated with data organization;
3. Explain the term "IBM compatible;"
4. Define terminology associated with basic network concepts;
5. Use File Manager in Windows to view the directory structure of a disk, to view the contents of a directory, and to change the display of a file list; and,
6. Use Windows Explorer in Windows 95 to view the directory structure of a disk, to view the contents of a directory, and to change the display of a file list.

Summary:

Review the concepts covered in this module in preparation for the self-assessment.

Next Lesson Assignment:

MASTER Technical Module (MFG-I2) dealing with understanding computer terminology.

MFG-I1-HO
Use Computer Operating Systems
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to:

- a. Distinguish between a directory/file folder and a file;
- b. Understand data organization and terminology;
- c. Explain the function of an operating system;
- d. Explain what the term "IBM compatible" means;
- e. Use a mouse;
- f. Utilize file manager in Windows 3.1 to view directories and files;
- g. Utilize explorer in Windows 95 to view folders and files; and,
- h. Explain and use basic network concepts.

Module Outline:

- I. Introduction to Computers
  - A. Discuss hardware components
  - B. Explain disk drive configurations
  - C. Discuss software
    - 1. Application programs
    - 2. Operating systems
      - a. DOS
      - b. Windows
      - c. Windows 95
      - d. Network operating systems
  - D. Discuss brands of computers
    - 1. Apple & MacIntosh
    - 2. IBM & compatibles
  - E. Explain data organization
    - 1. Files
    - 2. Filenames and extensions
    - 3. Root directory & backward slash (\)
    - 4. Directory and subdirectory structure
  - F. Explain the terms directory path and file specification
- II. Introduction to the Windows Operating System
  - A. Discuss how to start Windows
  - B. Discuss basic mouse operations
    - 1. Pointing
    - 2. Clicking
    - 3. Double clicking
    - 4. Dragging

- C. Discuss Windows elements
  - 1. Window borders
  - 2. Title bar
  - 3. Control-menu box
  - 4. Mouse pointer
  - 5. Sizing buttons
  - 6. Scroll bar and arrows
  - 7. Menu bar
  - 8. Pull-down menus
  - 9. Work area
  - 10. Icons
- D. Use File Manager
  - 1. Explain the file manager screen
  - 2. Change drives
  - 3. Expand directories
  - 4. Collapse directories
  - 5. Change file information displayed
  - 6. Run an application
- E. Run an application from an icon in Program Manager

III. Introduction to Windows 95 Operating System
- A. Discuss Windows 95 desktop components
  - 1. My Computer icon
  - 2. Recycle Bin icon
  - 3. Network Neighborhood icon
  - 4. Start button
  - 5. Taskbar
- B. Use Windows 95
  - 1. Open a window from an icon
  - 2. Use sizing buttons and close button
  - 3. Discuss Start menu
  - 4. Open an application using the Start button
  - 5. Explain shut down menu under Start
  - 6. Use Windows Explorer
    - a. Explain Windows Explorer toolbar buttons
    - b. Explain folders and subfolders
    - c. Select folders
    - d. Open and close folders
    - e. Change drives
    - f. Change file list display

IV. Introduction to Computer Network Systems
- A. Explain what a network is
- B. Discuss basic network components
  - 1. File server
  - 2. Network operating system (NOS)
  - 3. Local area network (LAN) cable

    4. Network devices
- C. Explain types of networks
    1. Campus
    2. National
    3. International
- D. Explain and use basic network concepts
    1. File server login/logout
    2. Application sharing
    3. Document sharing
    4. Electronic mail

MFG-I1-LW1
Use Computer Operating Systems
Attachment 2: **MASTER** Laboratory Worksheet No. 1

Introduction to Using Windows 3.1

1. Double-click the Main Group and open the File Manager. Click Tree and choose Indicate Expandable Branches, if it has not been selected. What lets you know this selection has been made? What does this selection do?

2. Select the root of drive C. Choose Tree from the command bar. Then clock Collapse Branch. What does this selection do?

3. Choose Tree again and click Expand One Level. How many directories/folders are on drive C?

4. In the command bar, select Tree and choose Expand All. What happened?

5. Find the folder WPWIN. How many subdirectories/subfolders are listed under the directory/folder name TEMPLATE?

6. Double-click a directory/folder that contains a subdirectory/subfolder. What happened?

7. What happens if you double-click the folder again?

8. Place a disk in drive A. How can you view the contents of the file in drive A?

9. Select drive C again. Under View, choose All File Details. What happened?

10. Select the MACROS subdirectory/subfolder under WPWIN. Go to View and choose Sort by Name. What is the first file listed?________________________

    Sort by Type. The first file listed is ____________________________________

Sort by Size. The first file listed is ______________________________

Sort by Date. The first file listed is ______________________________

11. How can the list of files in a particular folder be viewed?

____

12. Exit File Manager and close the Main Group. How did you do this?

____

13. How could an application package, such as WordPerfect for Windows, be loaded and run from Windows 3.1?

____

MFG-I1-LW2
Use Computer Operating Systems
Attachment 3: **MASTER** Laboratory Worksheet No. 2

Introduction to Using Windows 95

1. Click Start, go to Programs, and click Windows Explorer.
2. Maximize the window, if necessary.
3. Click in the square to the left of the My Computer icon.
4. What does a + in the square mean? What happens when you click the +?
5. What does a - in the square mean? What happens when you click the -?
6. Click on C:. How many directories/folders are at the root of drive C? How many files are at the root of drive C?
7. Expand drive C. How may directories under drive C are expandable?
8. How do you expand and collapse directories/folders?
9. Click View and select Details, what happened?
10. Put a disk in drive A and select drive A. How many directories/folders and files are at the root of drive A?
11. Select drive C again and open the DOS folder. How can you sort the file list by name, type, size, or date?
12. Exit Explorer. How did you do this?

13. **How do you run an application package, such as WordPerfect, from Windows 95?**

____

MFG-I1-LW3
Using Computer Operating Systems
Attachment 4: **MASTER** Laboratory Worksheet No. 3

Introduction to Using Networks

1. Locate the file server? Where is it?

2. What type of NOS is being used in this lab?

3. How do you login to the file server? What is the purpose of this?

4. Can you send an e-mail message in this lab? If so, what steps must be taken to do this?

5. What type of "sharing" can be done?

6. How can the directory structure of the file server be viewed?

7. Logout of the network. What is the purpose of this?

Name:__________________________ Date:_____________________

MFG-I1
Use Computer Operating Systems
Self-Assessment

1. Explain the function of an operating system?

____

2. What does the term "IBM compatible" mean?

____

3. Create your own names for directories/folders and files to design a directory structure containing three directories at the root. The first directory is to hold two files and one subdirectory. The second directory is to hold two subdirectories with one file in each subdirectory. The third directory should contain five files.

4. What is a directory/folder?

____

5. What does the term "path" mean?

____

6. What is a file specification?

____

7. What does the backward slash (\) represent?

____

8. What is a network and what are the basic network components?

____

9. What do the acronyms NOS and LAN stand for?

____

10. What is the purpose of logging into a network?

11. What is the purpose of logging out of a network?

12. What is meant by application sharing?

13. What is meant by document sharing?

14. What is electronic mail?

THE FOLLOWING QUESTIONS CONCERN WINDOWS 3.1.

15. When using Windows 3.1, how can the directory structure of a disk be viewed?

16. Using Windows 3.1, write how to do each of the following:

    a. View the directory contents of a different drive

    b. Expand and collapse a directory

    c. Change the file information displayed

17. How do you run an application such as Lotus 123 or WordPerfect from Windows 3.1?

18. What are the rules for naming files in Windows 3.1?

THE FOLLOWING QUESTIONS CONCERN WINDOWS 95.

19. When using Windows 95 how can the directory structure of a disk be viewed?

20. Using Windows 95, write how to do each of the following:

    a. Open and close a folder

    b. View directory contents of a different drive

    c. Change the file list display

21. How can directories/folders be distinguished from files?

22. How do you run an application, such as Lotus 123, from Windows 95?

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-I2

Subject: Manufacturing Technology **Time:** 12 Hrs.

Duty: Use Computers
Task: Understand Computer Terminology

Objective(s):

Upon completion of this unit the student will be able to:

a. Explain what RAM is;
b. Explain what ROM is;
c. Explain memory caching;
d. Define and convert bytes, kilobytes, and megabytes;
e. Discuss the function of a central processing unit;
f. Discuss processor speed; and,
g. Understand RS-232 protocol.

Instructional Materials:

MASTER Handout (MFG-I2-HO)
MASTER Self-Assessment

References:

Student Preparation:

Students should have previously completed the following technical modules:
MFG-I1 "Use Computer Operating Systems"

Introduction:

In order for the machinists to maximize the use of the computer and its related software, it is important that they have a conceptual understanding of how information and data are managed and processed within the computer. This module will introduce the student to the computer's brain, memory, and basic design for getting things done that are of value to the user.

Presentation Outline:

- I. Explain What Memory Is
  - A. RAM
  - B. ROM
  - C. Cache memory
  - D. Measuring memory
    - 1. Byte
    - 2. Kilobyte
    - 3. Megabyte
- II. Discuss Purpose and Function Of:
  - A. Central Processing Units (CPUs)
  - B. Processor performance
    - 1. Speed
    - 2. Generation
    - 3. Type
  - C. RS-232 serial port
- III. Determine the Amount of Available Memory on a System
  - A. Choose About from the Help menu in Program Manager for Windows 3.1
  - B. Choose About from the Help menu in Windows Explorer for Windows 95

Evaluation and/or Verification:

Successful completion of this technical module will be determined by the student's ability to successfully demonstrate the following competencies:

1. Define RAM and explain its function;
2. Define ROM and explain its function;
3. Explain the value of memory caching;
4. Explain the function of the CPU;
5. Determine the faster processor speed and explain what determines the speed;
6. Convert between bytes, kilobytes, and megabytes; and,
7. Explain the significance of a RS-232 serial port.

Summary:

Review the concepts covered in this module in preparation for the self-assessment.

Next Lesson Assignment:

MASTER Technical Module (MFG-I3) dealing with the use of file management systems.

MFG-I2-HO
Understand Computer Terminology
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Explain what RAM is;
b. Explain what ROM is;
c. Explain memory caching;
d. Define and convert bytes, kilobytes, and megabytes;
e. Discuss the function of a central processing unit;
f. Discuss processor speed; and,
g. Understand RS-232 protocol.

Module Outline:

I. Explain What Memory Is
  A. RAM
  B. ROM
  C. Cache memory
  D. Measuring memory
    1. Byte
    2. Kilobyte
    3. Megabyte
II. Discuss Purpose and Function Of:
  A. Central Processing Units (CPUs)
  B. Processor performance
    1. Speed
    2. Generation
    3. Type
  C. RS-232 serial port
III. Determine the Amount of Available Memory on a System
  A. Choose About from the Help menu in Program Manager for Windows 3.1
  B. Choose About from the Help menu in Windows Explorer for Windows 95

Name: Date:

MFG-I2
Understand Computer Terminology
Self-Assessment

1. What is RAM and explain its function.

2. What is ROM and explain its function.

3. What does the term "memory caching" mean?

4. What is the function of the CPU?

5. Circle the faster processor speed and explain why it is faster.
   - a. 33-MHz 80486 or 20-MHz 80486
   - b. 20-MHz 80486 or 33-MHz 80386

6. Fill in the blanks below.

1800 bytes = ______ KB

2 KB = ______ bytes

4 megabytes = ______ bytes

500 MB = ______ kilobytes

1,000,000 bytes = ______ megabytes

3300 kilobytes = ______ MB

7. What is the significance of a RS-232 serial port?

____

____

MFG-I3

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-I3

Subject: **Manufacturing Technology** **Time: 12 Hrs.**

Duty: **Use Computers**
Task: Use File Management Systems

Objectives:

Upon completion of this unit the student will be able to:

a. Explain file management concepts;
b. Create and delete directories/folders;
c. Copy a file(s) from one directory to another;
d. Copy a file(s) between a floppy disk and a hard drive;
e. Rename, move, and delete a file(s); and,
f. Format disks and make system disks.

Instructional Materials:

Data Disks
MASTER Handout (MFG-I3-HO)
MASTER Laboratory Worksheets(MFG-I3-LW1; MFG-I3-LW2)
MASTER Self-Assessment

References:

Windows 3.1 and/or *Windows 95 Computer Lab,* Latest Edition
Using Windows 3.1 to Perform File Management Operations, Latest Edition
Using Windows 95 to Perform File Management Operations, Latest Edition

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Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-I1 "Use Computer Operating Systems"
MFG-I2 "Understand Computer Terminology"

Introduction:

The understanding of files, file management systems, and the storage of files becomes important when one has entered information into the computer for processing. Since this is often a time consuming process in manufacturing, it becomes even more important that one understand the concepts. This module focuses on the development of competencies related to file management systems.

Presentation Outline:

- I. Explain and Discuss File Management Concepts
  - A. Copying a file(s)
  - B. Deleting a file(s)
  - C. Moving a file(s)
  - D. Renaming a file(s)
  - E. Creating a directory
  - F. Deleting a directory
  - G. Copying a disk
  - H. Formatting a disk
  - I. Making a system disk
- II. Use File Manager in Windows 3.1 to Perform File Management Operations
  - A. Use the file menu to:
    - 1. Create a directory
      - a. On the hard drive
      - b. On a floppy disk
    - 2. Copy a file(s)
      - a. From one directory to another
      - b. From a floppy disk to the hard drive
      - c. From the hard drive to a floppy disk
    - 3. Move a file(s)
    - 4. Rename a file(s)
    - 5. Delete a file(s)
    - 6. Delete a directory
  - B. Use the disk menu to:
    - 1. Copy a disk
    - 2. Format a disk
    - 3. Make a system disk
- III. Use Windows 95 to Perform File Management Operations
  - A. Use the file menu in Windows Explorer to:
    - 1. Create a new folder on the hard drive
    - 2. Create a new folder on the floppy drive
  - B. Use the edit menu in Windows Explorer to:
    - 1. Copy a file(s) from one directory to another
    - 2. Copy a file(s) from a floppy disk to the hard drive
    - 3. Copy a file(s) from the hard drive to a floppy disk
    - 3. Cut a file(s)
    - 4. Paste a file(s)
  - C. Use the file menu in Windows Explorer to:

        1. Rename a file(s)
        2. Delete a file(s)
        3. Delete a folder

D. Use My Computer on the Windows 95 desktop to:
        1. Format a disk
        2. Make a system disk

Practical Application:

Students will use Windows 3.1 and Windows 95 to complete the Laboratory Worksheets MFG-I3-LW1 and MFG-I3-LW2.

Evaluation and/or Verification:

Successful completion of this technical module will be determined by the student's ability to successfully demonstrate the following competencies in Windows 3.1 and/or Windows 95:

1. Create a directory/folder on a hard drive and a floppy disk;
2. Copy files from the hard drive to a floppy disk and from a floppy disk to a hard drive;
3. Rename a file;
4. Move a file;
5. Delete a file;
6. Delete a directory; and,
7. Format a system disk.

Summary:

Review the concepts covered in this module in preparation for the self-assessment.

Next Lesson Assignment:

MASTER Technical Module (MFG-I4) which deals with installing and using software packages.

MFG-I3-HO
Use File Management Systems
Attachment 1: MASTER Handout

Objectives:

Upon completion of this unit the student will be able to:
a. Explain file management concepts;
b. Create and delete directories/folders;
c. Copy a file(s) from one directory to another;
d. Copy a file(s) between a floppy disk and a hard drive;
e. Rename, move, and delete a file(s); and,
f. Format disks and make system disks.

Module Outline:

I. Explain and Discuss File Management Concepts
  A. Copying a file(s)
  B. Deleting a file(s)
  C. Moving a file(s)
  D. Renaming a file(s)
  E. Creating a directory
  F. Deleting a directory
  G. Copying a disk
  H. Formatting a disk
  I. Making a system disk
II. Use File Manager in Windows 3.1 to Perform File Management Operations
  A. Use the file menu to:
    1. Create a directory
      a. On the hard drive
      b. On a floppy disk
    2. Copy a file(s)
      a. From one directory to another
      b. From a floppy disk to the hard drive
      c. From the hard drive to a floppy disk
    3. Move a file(s)
    4. Rename a file(s)
    5. Delete a file(s)
    6. Delete a directory
  B. Use the disk menu to:
    1. Copy a disk
    2. Format a disk
    3. Make a system disk
III. Use Windows 95 to Perform File Management Operations

A. Use the file menu in Windows Explorer to:
   1. Create a new folder on the hard drive
   2. Create a new folder on the floppy drive

B. Use the edit menu in Windows Explorer to:
   1. Copy a file(s) from one directory to another
   2. Copy a file(s) from a floppy disk to the hard drive
   3. Copy a file(s) from the hard drive to a floppy disk
   3. Cut a file(s)
   4. Paste a file(s)

C. Use the file menu in Windows Explorer to:
   1. Rename a file(s)
   2. Delete a file(s)
   3. Delete a folder

D. Use My Computer on the Windows 95 desktop to:
   1. Format a disk
   2. Make a system disk

MFG-I3-LW1
Use File Management Systems
Attachment 2: **MASTER** Laboratory Worksheet No. 1

Using Windows 3.1 to Perform File Management Operations

*** A DATA DISK WILL BE NEEDED TO COMPLETE THESE EXERCISES. ***

1. Open the Main window and start File Manager.
2. Maximize the directory tree window.
3. View the contents of drive A and create a directory called RAINBOW.
4. View the contents of the hard drive by selecting the root icon for drive C.
5. Expand the directory named WINDOWS and view the files in the SYSTEM subdirectory.
6. Sort the files in SYSTEM by size and select the four smallest files.
7. Copy these files to the RAINBOW directory on drive A.
8. Check to see that these four files are still in the SYSTEM subdirectory. Now, view the contents of the RAINBOW directory on drive A to make sure the files were copied.
9. Rename each of the files under RAINBOW on drive A as Red, Blue, Green, and Yellow.
10. Create another directory on drive A named COLORS.
11. Move the files Red and Green from RAINBOW to COLORS.
12. Check to see that RAINBOW now contains only the files named Blue and Yellow.
13. Check to see that COLORS contains two files named Red and Green.
14. Delete the Yellow file in the RAINBOW directory.
15. Delete the RAINBOW directory.

16. Create a directory on the hard drive named your first name.

17. Copy the files on the disk in drive A to the directory on the hard drive with your name.

18. Format your data disk and then view its contents.

19. Make a system disk with your data disk. Use this system disk to restart the computer.

MFG-I3-LW2
Use File Management Systems
Attachment 3: **MASTER** Laboratory Worksheet No. 2

Using Windows 95 to Perform File Management Operations

*** A DATA DISK WILL BE NEEDED TO COMPLETE THESE EXERCISES. ***

1. Click START and choose Windows Explorer under Programs.
2. Maximize this window.
3. View the contents of your data disk in drive A and create a folder named SAMPLE on your data disk.
4. View the contents of the hard drive by selecting the root icon for drive C.
5. Expand the WINDOWS folder and view the files in the HELP subdirectory.
6. View the details of the files and arrange the files by size.
7. Select the four smallest files and copy them to the SAMPLE folder on drive A.
8. Check to see that these four files are still in the HELP folder on the hard drive. Now, view the contents of the SAMPLE folder on drive A to make sure the files were copied.
9. Rename each of the files under SAMPLE on drive A as File1, File2, File3, and File4.
10. Create another folder on drive A named EXERCISE.
11. Move the files File1 and File3 under SAMPLE to the folder named EXERCISE.
12. Check to see that SAMPLE now contains the files named File2 and File4.
13. Check to see that EXERCISE contains File1 and File3.
14. Delete File2 in SAMPLE.
15. Delete the folder SAMPLE.

16. Create a folder on the hard drive named PRACTICE.

17. Copy the files on the disk in drive A to the PRACTICE folder on the hard drive.

18. Format your data disk. Does it still contain your files?

19. Make your data disk a system disk. Explain the value of having a system disk.

Name:______________________________ Date:________________________

MFG-I3
Use File Management Systems
Self-Assessment

Use Windows 3.1 or Windows 95 to perform the following operations. You will need two data disks. Please turn in *both* disks to the instructor when you have completed the following tasks.

1. Create a directory/folder on the hard drive using TEST as the directory/folder name.

2. Copy any three files from the hard drive into TEST.

3. Create a directory/folder on one of your data disks using MINE as the directory/folder name.

4. Move the three files in TEST on the hard drive to MINE on the floppy disk.

5. In the MINE directory/folder, rename each of the files as File1, File2, and File3.

6. Copy File1, File2, and File3 to the TEST directory/folder on the hard drive.

7. Delete File1 in the MINE directory/folder on the data disk.

*** ASK THE INSTRUCTOR TO WATCH AS YOU PERFORM TASK #8. ***

8. Delete the TEST directory/folder on the hard drive.

9. Use a second data disk to make a system disk.

10. What is a system disk?

____

____

MFG-I4

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-I4

Subject: **Manufacturing Technology** **Time: 12 Hrs.**

Duty: **Use Computers**
Task: Install and Use Software Packages

Objectives:

Upon completion of this unit the student will be able to:

a. Install a software package to a hard disk;
b. Configure the system parameters upon installation;
c. Create a word processing document;
d. Create a spreadsheet; and,
e. Open, edit, enhance, save, and print word processing and spreadsheet files.

Instructional Materials:

Data Disks
Creating a Word Processing Document
Creating a Spreadsheet
MASTER Laboratory Worksheets (MFG-I4-LW1; MFG-I4-LW2)
MASTER Self-Assessment

References:

Windows 3.1 and/or *Windows 95 Computer Lab*, Latest Edition
Software package to install from CD
Software package to install from diskettes
Word processing software
Spreadsheet software

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-I1	"Use Computer Operating Systems"
MFG-I2	"Understand Computer Terminology"
MFG-I3	"Use File Management Systems"

Introduction:

In order to process data, computers need a set of instructions to tell it what to do. These instructions are called programs. Since machinists will want to use programs that perform certain tasks, it is important that they understand how to install, configure, and use software. That is the purpose of this module.

Presentation Outline:

I. Explain How to Install Software Packages Using Windows 3.1
    A. Install from a CD-ROM
    B. Install from diskettes
II. Explain How to Install Software Packages Using Windows 95
    A. Install from a CD-ROM
    B. Install from diskettes
III. Explain How to Configure System Parameters for a Software Package
    A. Modification to AUTOEXEC.BAT and CONFIG.SYS
    B. Modification of INI files (e.g. WIN.INI, SYSTEM.INI)
    C. Plotter/printer driver configurations
    D. Digitizer pad/mouse driver configurations
IV. Use a Word Processor Software Package (e.g. WordPerfect, MS Word)
    A. Typing a document
    B. Using cursor movement keys
    C. Editing a document with backspace and delete
    D. Using the spelling checker
    E. Saving a file
    F. Printing a file
    G. Closing a file
    H. Opening a file
    I. Changing the margins
    J. Using bold, italics, and underline
    K. Changing alignment
V. Use a Spreadsheet Software Package (e.g. Lotus 123, MS Excel)
    A. Entering values and labels
    B. Editing the spreadsheet
    C. Using formulas and functions
    D. Changing column widths
    E. Changing number format
    F. Changing alignment
    G. Copying formulas and functions
    H. Printing the spreadsheet
    I. Saving the spreadsheet and chart

Practical Application:

Students can perform practical applications by installing software packages to a hard disk and answering system parameter prompts during the installation. Students will create word processing and spreadsheet documents by completing the Laboratory Worksheets MFG-I4-LW1 and MFG-I4-LW2.

Evaluation and/or Verification:

Successful completion of this technical module will be determined by the student's ability to successfully demonstrate the following competencies:

1. Install a software package and give proper system parameters;
2. Create, save, and print a word processing document; and,
3. Create, save, and print a spreadsheet.

Summary:

Review the concepts covered in this module in preparation for the self-assessment.

Next Lesson Assignment:

MASTER Technical Module (MFG-J1) dealing with TQM in manufacturing.

MFG-I4-HO
Install and Use Software Packages
Attachment 1: MASTER Handout

Objectives:

Upon completion of this unit the student will be able to:

a. Install a software package to a hard disk;
b. Configure the system parameters upon installation;
c. Create a word processing document;
d. Create a spreadsheet; and,
e. Open, edit, enhance, save, and print word processing and spreadsheet files.

Module Outline:

I. Explain How to Install Software Packages Using Windows 3.1
  A. Install from a CD-ROM
  B. Install from diskettes
II. Explain How to Install Software Packages Using Windows 95
  A. Install from a CD-ROM
  B. Install from diskettes
III. Explain How to Configure System Parameters for a Software Package
  A. Modification to AUTOEXEC.BAT and CONFIG.SYS
  B. Modification of INI files (e.g. WIN.INI, SYSTEM.INI)
  C. Plotter/printer driver configurations
  D. Digitizer pad/mouse driver configurations
IV. Use a Word Processor Software Package (e.g. WordPerfect, MS Word)
  A. Typing a document
  B. Using cursor movement keys
  C. Editing a document with backspace and delete
  D. Using the spelling checker
  E. Saving a file
  F. Printing a file
  G. Closing a file
  H. Opening a file
  I. Changing the margins
  J. Using bold, italics, and underline
  K. Changing alignment
V. Use a Spreadsheet Software Package (e.g. Lotus 123, MS Excel)
  A. Entering values and labels
  B. Editing the spreadsheet
  C. Using formulas and functions
  D. Changing column widths

E. Changing number format
F. Changing alignment
G. Copying formulas and functions
H. Printing the spreadsheet
I. Saving the spreadsheet and chart

MFG-I4-LW1
Install and Use Software Packages
Attachment 2: **MASTER** Laboratory Worksheet No. 1

Creating a Word Processing Document

I. Creating Documents

A. Key the following document in a word processing software package.

The Vernier Caliper

The basic parts of a vernier caliper are a main scale which is similar to a steel rule with a fixed jaw and a sliding jaw with a vernier scale. They are available in a wide range of lengths with different types of jaws and scale graduations.

B. Check your spelling.

C. Save the document on your data disk as CALIPERS and print.

D. Close the document.

E. Create another new document and enter the text below.

Micrometers

Micrometers are basic measuring instruments used by machinists in the processing and checking of parts. They are available in a wide range of sizes and types.

Outside micrometers are used to measure dimensions between parallel surfaces of parts and outside diameters of cylinders. Other types, such as depth micrometers, screw thread micrometers, disc and blade micrometers, and inside micrometers, also have wide application in the machine shop.

F. Boldface and italicize the title.

G. Change the top margin to 2.8 inches and check the spelling.

H. Save the document on your data disk under the name MICS and print.

I. Close the document.

II. Opening Documents and Editing

A. Open the document CALIPERS.

B. Insert Decimal-Inch in the title between "The" and "Vernier", so the title will read The Decimal-Inch Vernier Caliper. Also, boldface the title.

C. Insert the following text as the second sentence.

The vernier scale slides parallel to the main scale and provides a degree of precision to 0.001".

D. In the last sentence, change "They" to "Calipers".

E. Change the top margin to 2.7 inches and check your spelling.

F. Save under the same name and print.

G. Open the document MICS.

H. Make the two paragraphs one.

I. Save the document under the same name and print.

MFG-I4-LW2

Install and Use Software Packages

Attachment 3: **MASTER** Laboratory Worksheet No. 2

Creating a Spreadsheet

I. Create a Spreadsheet, Change Column Widths, and Alignment

A. Enter the following labels as shown below to create a spreadsheet. Change the column width as necessary.

Diametral Pitch	Number of Teeth	Pitch Diameter (inches)	Addendum (inches)	Dedendum (inches)

B. Center the labels in the cells.

C. In the Diametral Pitch column enter the following values: 4, 6, 8, and 3.

D. In the Number of Teeth column enter the following values: 45, 75, 44, and 54.

E. Save the spreadsheet to your data disk as BEVEL and print.

F. Open a new document and enter the following information below. Change the column widths as necessary.

Name	Rate	Hours	Gross Pay
Natalie Nicholson	6.80	40	
Dave Miller	8.60	40	
Karen Lark	8.60	38	
Taylor Smithsonian	5.50	20	

G. Center the values in the Hours column.

H. Set the number format in the Rate column to show two decimal places and the number format in the Hours column to show zero decimal places.

I. Save the spreadsheet to your data disk as PAYROLL and print.

II. Create and Copy Formulas/functions and Edit the Spreadsheet

A. Place BEVEL back on your desktop.

B. Enter the following formulas in the appropriate cell and copy to other cells where the formula is needed.

Pitch Diameter = Number of Teeth / Diametral Pitch
Dedendum = 1.157 / Diametral Pitch
Addendum = 1/ Diametral Pitch

C. Save under the same name and print.

D. Change the Diametral Pitch in the first cell from 4 to 5.

E. Change the Number of Teeth in the last cell from 54 to 50

F. Add a Diametral Pitch of 10 with the Number of Teeth given as 80.

G. Copy the formulas to the new row.

H. Save and print.

I. Place PAYROLL back on the desktop and enter the formula to compute the Gross Pay. (Gross Pay = Rate * Hours)

J. Format the Gross Pay as currency.

K. Add the Hours column.

L. Change Dave Miller's rate of pay to $9.00.

M. Save and print.

Name:________________________ Date:____________________

MFG-I4
Install and Use Software Packages
Self-Assessment

1. **Install the software package assigned to you by your instructor and give the proper system parameters.**

2. Create the following word processing document.

(date)

Mr. Eric Brown
Director of Personnel
Mason Manufacturing Company
Crestview Drive
Franklin, MS 38801

Dear Mr. Brown:

I read your advertisement seeking a manufacturing technician for your company. Please consider this letter as my application for the position.

I received my Associate of Applied Science degree in Manufacturing Technology from Texas State Technical College in Waco, Texas. Presently I am a manufacturing technician. I have held this position for four years with Acme Tool and Die in Waco, Texas.

As a manufacturing technician I have had experience in conventional machine operations, CNC mill and CNC wire EDM operations, and CAM programming. I have just received my certification as a journeyman, but presently there are no positions available in my present place of employment.

Sincerely,

(your name)

Enclosure

3. Save the document on your data disk under the name MASON and print.

4. Boldface “manufacturing technician” in the first paragraph.

5. Add the following as the fourth paragraph:

   I have enclosed my resume which will supply you with more specific information about my background and present employment. I would very much appreciate an interview with you.

6. Save the document again and print.

7. Create the following spreadsheet. Right align the labels.

Circular Pitch (inches)	Working Depth (inches)	Clearance (inches)	Tooth Thickness (inches)
0.3925			
0.1582			
0.8069			
1.2378			
1.5931			

8. Enter the following formulas into the appropriate cell and use copy to place the formula in the other cells.

   Working depth = 0.6366 * Circular Pitch
   Clearance = 0.05 * Circular Pitch
   Tooth thickness = 0.5 * Circular Pitch

9. Save the spreadsheet as SPUR and print.

10. Change the last measurement in the Circular Pitch column to 1.1359.

11. Save the spreadsheet again and print.

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

Duties		Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/decimals	B-3 Convert Metric/English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MFG FM4
[illegible]

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-J1

Subject: **Manufacturing Technology** **Time: 20 Hrs.**

Duty: **Participate in Total Quality and SPC Activities**
Task: Discuss TQM in Manufacturing

Objective(s):

Upon completion of this unit the student will be able to:

a. Understand the history of Total Quality Management process and its major historical contributors - Deming, Juran, and Crosby;
b. State the reason for intensive application of Total Quality Management principles, concepts and constitution parts in the industrial work places of America;
c. Identify the parts of the of the Total Quality Management formula (or the major element of TQM) - TQM=(T^5 + SPC) X CI(CF) + E&CS = P&S;
d. Understand the vital interplay of Training, Trust, Teamwork, Total Involvement and Transformation (T^5) to the successful implementation of TQM^2;
e. Understand the need for quantitative tools to base quality decisions on objective measurable information (Statistical Process Control - SPC);
f. Understand how Continuous Improvement (CI) with a Customer Focus (CF) is a vital philosophy with the power to multiply quality efforts of TQM$^{2:}$
g. State the importance of Employee and Customer Satisfaction (E&CS) to the successful implementation of TQM^2;
h. Understand how the meaning of quality is determined based on the prospective of supplier and customer;
i. Understand that the quality perceptions of the customer are of prime importance;
j. Identify external and internal customers and the importance of both to the successful implementation of TQM^2;
k. Know the essential importance of the Total Quality Management formula and its constitution parts to the Profitability and Survivability of a manufacturing enterprise; and,
l. Understand the importance of National TQM awards.

Instructional Materials:

MASTER Handout (MFG-J1-HO1)
MASTER Handout/Overheads (MFG-J1-HO2)
Videos "Quality or Else, Parts I, II, and III" (IBM PBS Series).
Quality or Else: A Course of Study in 15 Sessions - Participant Notebook by Savary, Latest Edition (the course textbook)

References:

Quality Planning and Analysis, Juran and Gryna, McGraw-Hill, Inc., Publishers, Latest Edition
Quality or Else: The Revolution in World Business - A Companion to the IBM-Funded PBS Series, Dobyns and Crawford-Mason, Houghton Mifflin Publishers, Latest Edition
Putting Total Quality Management to Work: What TQM Means, How to Use It & How to Sustain It Over the Long Run, Sashkin and Kiser, Berrett- Koehler Publishers, Latest Edition
Total Quality Management: Three Steps to Continuous Improvement, Tenner and DeToro, Addison Wesley Publishers, Latest Edition
Videos: *In Search of Excellence,* Nathan/Tyler Productions, Inc., Latest Edition
Passion for Excellence, Video Publishing House, Inc., Latest Edition
The Quality Revolution, Parts I, II, and III, PBS Series, Latest Edition

Student Preparation:

Students will have read and studied pages 1-19 in the textbook *Quality Or Else: A Course of Study Participant Notebook.* This section in the text provides a general introduction to Total Quality Management and the Global Marketplace.

Introduction:

Every aspect of our lives, from the clothes we wear to the cars we drive, to the wages we earn and to the retirement years we may enjoy, are affected by the quality of goods produced in the United States and the Global Marketplace. The Global Marketplace is an increasing reality fueled by transportation and information technology, both of which are advancing at rapidly increasing rates. Local, regional and national marketplaces have been replaced by a global marketplace, and if we are to compete globally, we must learn to produce quality goods that permit us to compete based on economies of quality as well as economies of quantity.

Presentation Outline:

NOTE: Prior to presenting Total Quality Management the instructor should review all the Instructional Videos and the Textbook, as well as the reference material, and determine how much material can be presented based on the time allowed. Once this determination is made the instructor can use the Textbook, modifying its format to present the appropriate material. The Textbook contains fifteen sessions that cover all three parts of the accompanying video. Total time to do all fifteen sessions would be 16-20 hours depending on classes size and participation.

I. Discuss the History of Total Quality Management Process and its Major Historical Contributors - Deming, Juran, and Crosby
II. Discuss the Reason for Intensive Application of Total Quality Management Principles, Concepts and Constitution Parts in the Industrial Work Places of America
III. Discuss the Parts of the of the Total Quality Management Formula (Or the Major Element of TQM) - $TQM=(T^5 + SPC) X CI(CF) + E\&CS = P\&S$
IV. Discuss the Vital Interplay of Training, Trust, Teamwork, Total Involvement and Transformation (T^5) to the Successful Implementation of TQM^2
V. Discuss the Need for Quantitative Tools to Base Quality Decisions on Objective Measurable Information (Statistical Process Control - SPC)
VI. Discuss How Continuous Improvement (CI) With a Customer Focus (CF) Is a Vital Philosophy with the Power to Multiply Quality Efforts of TQM^2
VII. Discuss the Importance of Employee and Customer Satisfaction (E&CS) to the Successful Implementation of TQM^2
VIII. Discuss How the Meaning of Quality Is Determined Based on the Prospective of Supplier and Customer
IX. Discuss the Quality Perceptions of the Customer That Are of Prime Importance
X. Discuss External and Internal Customers and the Importance of Both to the Successful Implementation of TQM^2
XI. Discuss the Essential Importance of the Total Quality Management Formula and its Constitution Parts to the Profitability and Survivability of a Manufacturing Enterprise
XII. Discuss the Importance of National TQM Awards

Practical Application:

Students will view the videos and complete the instructional material in the textbook, take notes, participate in discussions and exercises, all of which will bring the students to a mastery of TQM.

Evaluation and/or Verification:

Successful completion of the module will be based on the student's demonstration of the ability to:

a. Understand the history of Total Quality Management process and its major historical contributors - Deming, Juran, and Crosby;

b. State the reason for intensive application of Total Quality Management principles, concepts and constitution parts in the industrial work places of America;

c. Identify the parts of the of the Total Quality Management formula (or the major element of TQM) - $TQM=(T^5 + SPC) X CI(CF) + E\&CS = P\&S$;

d. Understand the vital interplay of Training, Trust, Teamwork, Total Involvement and Transformation (T^5) to the successful implementation of TQM^2;

e. Understand the need for quantitative tools to base quality decisions on objective measurable information (Statistical Process Control - SPC);

f. Understand how Continuous Improvement (CI) with a Customer Focus (CF) is a vital philosophy with the power to multiply quality efforts of TQM^2

g. State the importance of Employee and Customer Satisfaction (E&CS) to the successful implementation of TQM^2;

h. Understand how the meaning of quality is determined based on the prospective of supplier and customer;

i. Understand that the quality perceptions of the customer are of prime importance;

j. Identify external and internal customers and the importance of both to the successful implementation of TQM^2;

k. Know the essential importance of the Total Quality Management formula and its constitution parts to the Profitability and Survivability of a manufacturing enterprise; and,

l. Understand the importance of National TQM awards.

The Self-Assessments for this module are found in the Participant Notebook.

Summary:

Review the main lesson points using the textbook, hold class discussion and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-J2) dealing with demonstrating quality problem solving techniques.

MFG-J1-HO1
Discuss TQM in Manufacturing
Attachment 1: **MASTER** Handout No. 1

Objective(s):

Upon completion of this unit the student will be able to:

a. Understand the history of Total Quality Management process and its major historical contributors - Deming, Juran, and Crosby;
b. State the reason for intensive application of Total Quality Management principles, concepts and constitution parts in the industrial work places of America;
c. Identify the parts of the of the Total Quality Management formula (or the major element of TQM) - TQM=(T^5 + SPC) X CI(CF) + E&CS = P&S;
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j. Identify external and internal customers and the importance of both to the successful implementation of TQM^2;
k. Know the essential importance of the Total Quality Management formula and its constitution parts to the Profitability and Survivability of a manufacturing enterprise; and,
l. Understand the importance of National TQM awards.

Module Outline:

I. Discuss the History of Total Quality Management Process and its Major Historical Contributors - Deming, Juran, and Crosby
II. Discuss the Reason for Intensive Application of Total Quality Management Principles, Concepts and Constitution Parts in the Industrial Work Places of America

III. Discuss the Parts of the of the Total Quality Management Formula (Or the Major Element of TQM) - $\text{TQM}=(\text{T}^5 + \text{SPC}) \text{ X } \text{CI}(\text{CF}) + \text{E\&CS} = \text{P\&S}$

IV. Discuss the Vital Interplay of Training, Trust, Teamwork, Total Involvement and Transformation (T^5) to the Successful Implementation of TQM^2

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IX. Discuss the Quality Perceptions of the Customer That Are of Prime Importance

X. Discuss External and Internal Customers and the Importance of Both to the Successful Implementation of TQM^2

XI. Discuss the Essential Importance of the Total Quality Management Formula and its Constitution Parts to the Profitability and Survivability of a Manufacturing Enterprise

XII. Discuss the Importance of National TQM Awards

MFG-J1-HO2
Discuss TQM in Manufacturing
Attachment 2: **MASTER** Handout No. 2

Handouts/Overheads

1 handouts/overheads

TQM FORMULA

$$TQM=(T^5+SPC) \times CI(CF) + E\&CS=P\&S$$

T^5 = Training
Trust
Teamwork
Total Involvement
Team Formation
SPC = Statistical Process Control
CI = Continuous Improvement
CF = Customer Focus
E&CS = Employee &Customer Satisfaction
P&S = Profit & Survivability

2 handouts/overheads

Customer and Perception:

Customers perceive the quality of a service by comparing the actual service to what their expectations of service were before using or purchasing the service.

Service is judged to be unsatisfactory when expectations are not met.

Satisfactory when expectations are met and more than satisfactory when expectations are exceeded.

Successful organizations are able to diagnose the full set of customers' expectations and satisfy them completely, every time.

World class organizations have the ability of understanding implicit and even latent requirements of customers.

These latent requirements are features that customers want but do not know are available and hence are unable to articulate in discussion with suppliers.

Expectations and thus perceptions can be determined by answering 4 key questions:

1. What product/service characteristics do customer want?
2. What performance level is needed to satisfy their expectations?
3. What is the relative importance of each characteristic?
4. How satisfied are customers with performance at the current level?

4 handouts/overheads

Characteristics of Quality Service:

Customers expect to receive value in the products and services they purchase or use.

Value can be defined as the relationship between what customers get in exchange for what they give. This has usually been considered as the trade-off between price and quality, but more is involved.

CUSTOMER anyone to whom you (personally, your department, or the institution) provide service, product, or information. For many, your primary customer(s) will be other employees.

Performance Level Needed to Satisfy Expectations

3 Performance Levels:

Level 1 (Implicit) Base Expectations -
Minimum performance levels always assumed present

Level 2 (Explicit) Specifications and Requirements -
Options and trade-offs available for selection by customer

Level 3 (Latent) Delight -
Value Added characteristics and features that customers did not expect. Not just more; unanticipated.

What performance level is needed to satisfy expectations?

Service quality features are measured in subjective, qualitative terms based on observations and comparisons.

QUALITY:

A basic business strategy that provides goods and services that completely satisfy both internal and external customers by meeting their expectations.

This strategy utilizes the talents of all employees, to the benefit of the organization in particular and society in general, and provides a positive financial return to the shareholders.

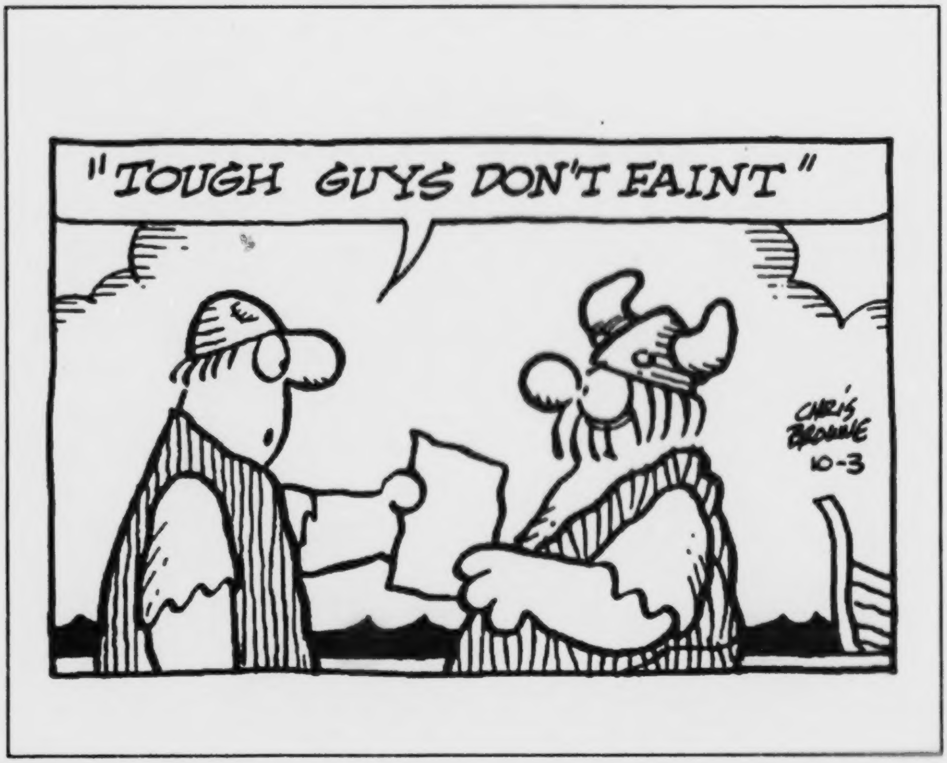
Total Quality Management:
Arthur R. Tenner & Irving J. DeToro

WHAT IS A TOTAL QUALITY MANAGEMENT SYSTEM?

Quality is not determined by the worker on the shop floor, nor is it determined by the service technician working at the customers's site.

Quality is determined by the senior managers of an organization, who by virtue of the positions they hold, are responsible to customers, employees, suppliers, and shareholders for the success of the business.

Total Quality Management:
Arthur R. Tenner & Irving J. DeToro


"TOUGH GUYS DON'T FAINT"
CHRIS BROWNE
10-3

SENIOR MANAGERS:

- Allocate resources
- Decide which markets the firm will enter
- Select and implement the management processes that will enable the firm to fulfill their mission and their vision

Formulating and devising the systems under which the workers perform their functions.

MOTIVATING FACTORS FOR TQM

---

1 Reality of the global market place

2 Competition in global market place means maximize savings by doing the job right the first time.

3 Speed of technology transfer makes for a level playing field and negates advantage.

4 Primary competitive advantages
   - People
   - Processes

5 TQM improves working environment which improves:
   - Morale
   - Employee retention

12 handouts/overheads

What is TQM?

> A philosophy of management

> A new way of thinking and conducting business

> A system that when implemented will bring about continuous improvement

> A structured system which will help you solve customer problems

> Using the collective knowledge and talents of all people in the organization

> Intensified by the use of statistical process controls

> Implemented now but will continue forever

CONTINUOUS IMPROVEMENT CONCEPT

Continuous improvement - is a philosophy and an attitude for analyzing capabilities and processes and improving them repeatedly to achieve one objective "customer satisfaction".

Customer satisfaction - result of meeting or exceeding customer expectations.

Value - relationship between quality and cost. Value is what the customer wants.

BASIC IDEA IN CONTINUOUS IMPROVEMENT

Empowering all people in a company to act on the basis of factual knowledge of the process in which they are involved will result in better products and services, delivered faster and at a greater profit.

CONTINUOUS IMPROVEMENT CONCEPT

Goal of customer satisfaction and value

Achieved by:

- Systematic analysis of what is being done, for whom, and why
- Application of process improvement methods

Focus of continuous improvement

. . . is on improving the work process (how things are done) by ourselves, our company and our suppliers.

CONTINUOUS IMPROVEMENT CONCEPT

Eliminate activities in the process:

- That add no value (what customer wants)
- Cause bottlenecks that block superior performance

Basic concept of continuous improvement:

Each person in a process is both a supplier and a customer. We gather the inputs we need for our work from our suppliers. Perform our work process producing output for our customers.

CONTINUOUS IMPROVEMENT CONCEPT

New culture at a company -
Culture that is more focused on satisfying requirements and expectations of both internal and external customers.

New culture characterized by improved methods of operation arising from:

- Participative management
- Teaming
- Process knowledge and improvement

Why:

- Increased competition
- Customer demand
- Needs of the work force

CUSTOMER ______

The next person (individual or group) in a process that receives your output and acts on it.

A customer may be:

- Internal
- External

Concept of **internal customers** is important because is has been shown that an organization cannot successfully meet the needs of its external customers if each output passed between employees within a company is deficient.

WHO IS MY CUSTOMER OR WHO ARE MY CUSTOMERS?

Answer 2 questions:

1. What is the output of my work?

   What is it I do?

2. Who receives the output of my work?

   For whom is it I do it for?

DETERMINE CUSTOMER EXPECTATIONS

Once customers are identified, their expectations can be determined by answering 4 key questions:

1. What product/service characteristics do customers want?
2. What performance level is needed to satisfy their expectations?
3. What is the relative importance of each characteristic?
4. How satisfied are customers with performance levels at the current level?

MAJOR ELEMENTS OF TQM

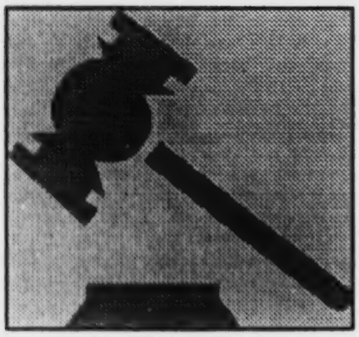
Total quality management . . .

- Depends on leadership from the highest levels of the organization
- Is focused on the requirements of the customer
- Requires cultural change involving:
  - Training
  - New processes
- Requires teamwork
- Involves continuous process improvement grounded on data based problem solving
- Requires long term commitment

CUSTOMER PERCEPTION

Customers tend to perceive the quality of a service by comparing actual service experienced to what their expectations and desire were before using or purchasing the service.

SERVICE IS JUDGED TO BE:



Unsatisfactory:
when expectations are not met.

Satisfactory:
when expectations are met.

Delight:
when expectations have been exceeded.

Successful Organizations

are able to diagnose the full set of customers' expectations and satisfy them completely,

World Class Organizations

have the ability of understanding implicit and even latent customer requirements.

Latent requirements are features that customers want but do not know are available and hence are unable to articulate in discussions.

Step 1 - Identify Customer

Who is my customer or who are my customers?

Answer 2 questions:

1. What is the output of my work?

   What is it I do?

2. Who receives the output of my work?

   For whom is it I do it for?

OUTPUTS the specific products or service that you produce, as part of your work process, and that you pass on to others, who, in turn, use them in their work process.

Output must be defined as specifically as possible.

Definitions like:

- Attitudes changed
- Work completed
- Too Vague
- Plans implemented

OUTPUT DEFINITIONS

Examples: ________________

Meeting... planned?
scheduled?
recorded?

Reports... researched?
typed?
distributed?
filed?

Classes... scheduled?
developed?
taught?

OUTPUTS ARE NOT:

- Things that you supervise or approve but things that are actually produce by others.
- Goals or outcomes for the organization.
- Steps in the work process.
- The overall function described by and individual's job title or responsibility.

CUSTOMER ______

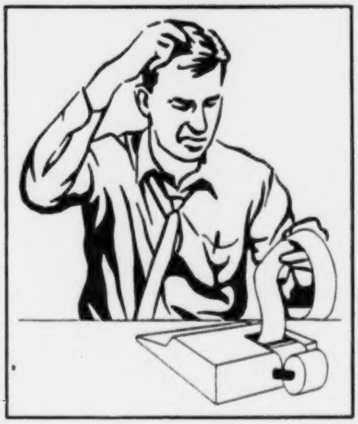
The next person (individual or group) in a process that receives your output and acts on it.

A customer may be:

- Internal
- External

Concept of internal customers is important because is has been shown that an organization cannot successfully meet the needs of its external customers if each output passed between employees within a company is deficient.

Step 2 - Determine Customer Expectations



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1. What product/service characteristics do customers want?
2. What performance level is needed to satisfy their expectations?
3. What is the relative importance of each characteristic?
4. How satisfied are customers with performance levels at the current level?

SERVICE CHARACTERISTICS:

Which are important to your customer's wants?

RELIABILITY: Consistency of performance and dependability.

- Performing the right service right the first time
- Honoring promises
- Accuracy

RESPONSIVENESS: Willingness or readiness of employees to provide service; timeliness.

COMPETENCE: Possession of the skills and knowledge required to perform the service.

ACCESS: Approachability and ease of access:

- Waiting time
- Hours of operation

COURTESY: Politeness, respect, consideration, and friendliness of contact personnel.

COMMUNICATIONS:

- Keeping customers informed in language they can understand
- Listening to customers
- Explaining the service itself
    - How much it will cost.
    - How problems will be handled.

CREDIBILITY:

- Trustworthiness
- Believability
- Honesty
- Institution's reputation
- Personal characteristics of personnel

SECURITY:

- Freedom from danger, risk or doubt
- Physical safety
- Confidentiality

UNDERSTANDING THE CUSTOMER:

- Making the effort to understand the customer's needs
- Learning the customer's specific requirements
- Providing individualized attention
- Recognizing the regular customer

TANGIBLES: Physical evidence of service:

- Physical facilities
- Appearance of personnel
- Tools or equipment used to provide service
- Other customers in service facility

APPLICATION OF THE 3 EXPECTATION LEVELS:

Recognizing the expectation level of any particular product/service characteristic offers three advantages:

First: It clarifies which characteristics should be discussed in detail with current or prospective customers.

Second: It helps to predict how the level of customer satisfaction might respond to a change in characteristics.

Third: It indicates possible future trends in expectations.

WHAT IS QUALITY?

(5 Definitions)

CONFORMANCE

If a box of cookies is to weigh 12 oz., conformance is boxes of cookies weighing a minimum of 12 oz., and a little more.

FITNESS FOR USE

Does the product perform a task as advertised?

This takes into account the design of the product not just its conformance to standards. Data on the fitness for use must be obtained "in the field."

RELIABILITY

Will the product perform its intended function in the specified environment for a prescribed length of time?

The time specified in a warranty indicates minimum length of time a product can be expected to perform satisfactorily.

Higher quality products generally come with longer warranty.

YIELD

What percent of products conform to specifications at each evaluation point?

Less waste means higher quality work. Higher in-plant product and process “yields” also tend to indicate better future product performances levels in the field.

CUSTOMER SATISFACTION

What value does the customer perceive?

Does the product meet customer expectations?

This is the **ULTIMATE** quality standard. Quality organizations provide products and services that go beyond customer satisfaction.

"Quality Is Job One"
(Ford)

"There is no substitute for quality.
Come home to quality."
(Anderson Windows)

"The Quality goes in before the name goes on!"
(Zenith)

"Quality starts with fundamentals"
(Raytheon)

"Our policy is quality"
(Paul Revere Life Insurance Co.)

Carnevale's, ***America and the New Economy***, economic change has been brought about by the following factors:

- globalization of wealth/economic activity
- introduction of new technologies
- diversification of taste
- increasing value of human time
- commercialization of free labor
- increased participation of consumers in production and service delivery
- technical advances

What happened to trigger loss of market for American products?

American indifference was the cause:

- Indifference to changing demands in national and foreign markets for quality goods
- Indifference to the maintenance of a competitive manufacturing infrastructure that could produce quality goods
- Indifference to workforce to help in production of quality goods

Europeans and Japanese could not out produce the U.S. so they devised market strategies that would take advantage of America's indifference. One of the important strategies was the development of flexible organizations that reduced cost by focusing on the ***work process*** and ***quality***.

It takes more than productivity and low prices to win the competitive race.

It also takes quality.

Quality is primary among the new competitive standards of the world.

American productivity in computer chips has been good as or better than that of our competitors, yet by the late 1970s, we lost our market share because our chips were not as reliable as those produced in Japan.

NEW COMPETITIVE STANDARDS

#1 Quality

Measure of performance of the product or delivery of the service.

#2 Productivity

Ratio of output, the results of production to the corresponding input during a given period of time.

#3 Variety

The standardized offering of mass production have given way to an explosion of choices. Example: Consumers don't want just soap they want different colors, sizes, fragrances. Americans now choose among 572 different models of cars, vans, and trucks, compared with 408 in 1980.

#4 Customization

Products are individualized to meet wants and desires of customers to have a product that will meet a certain need or job. People do not want standardized or cookie cutter items.

#5 Convenience

3 types:
Build in - product is easy to use

Delivery - ease of obtaining the product Customer

Service - how the customer is treated by the staff or company.

#6 Timeliness

Develop products or services that are innovations before someone else does.

Not all American quality is poor. America still sets the world's quality standards in industries such as:

- Aerospace
- Aircraft
- Large Computers
- Appliances

Motorola (MB Award 1988):

Lowered defect rate from more than 5,000 defects per 1,000,000 chips to 500 defects and to 3.4 defects per 1,000,000 chips.

Xerox (MB Award 1989):

Installed a TQM program and overtook the Japanese lead in the photocopier market.

Harley-Davidson:

Reduced a manufacturing defect rate of 50% in 1972 to 1% of production using TQM.

GE, Whirlpool, Maytag, and other American appliance manufactures:

Initiated quality improvements before being challenged by overseas competitors.

Evolution of Quality

"If you build a better mousetrap, customers will beat a path to your door."

Frederick W. Taylor - introduced the concept of scientific management, which meant scientifically determining the "one best way" of performing a task or job. His theory was that by using the scientifically determined "best way" of performing a task productivity would be increased to the financial benefit of both the employer and employee.

Walter A. Shewhart - working for Bell Telephone Laboratories is now recognized as the "father" of quality control.

In 1924, he described what is now known as a control chart.

In 1931, he published the first known statistical quality textbook.

He introduced the importance of placing a process under statistical control in order to improve the design process.

Harold F. Dodge & H.G. Romig - used statistical theory to develop sampling inspection. Dodge-Romig Sampling Inspection Tables.

1934 - General Leslie Simon started using statistical quality control at the Picantinny Arsenal.

1940 - War Department requests the American Standards Association to standardize quality control techniques. Appointed were Harold F. Dodge (chairman), A.G. Ashcroft, W. Edward Deming, Leslie Simon and Ralph Wareham. Developed American War Standards chart.

1946 - W. Edward Deming went to Japan after war to study agricultural production for the War Department. Convinces Kenichi Koyangagi, one of the founders of the Union of Japanese Scientists and Engineers, of the potential of statistical quality control.

1950 - Deming starts teaching in Japan SQC to many of the top Japanese industrial leaders. U.S. management beginning to abandon the precepts learned in the wartime QC courses.

Joseph M. Juran - developed the principles of quality control originally used in Japan and now used in most of the world.

Philip B. Crosby - created the concept of "Zero Defects."

Kaoru Ishikawa - had a key roll in the development of quality in Japan. The cause-and-effect diagram is named in his honor. Leader in the development of quality circles.

Genichi Taguchi - developed the philosophy for a complete and integrated system to develop specifications, engineer the design to these specifications and manufacture the product to specifications.

QUALITY IS....

Meeting or exceeding your customer's expectations and requirements.

Requirements that are determined or modified through continuous communications between customers, workforce, and management.

Deming, 1986

What is TQM?

> A philosophy of management
> A new way of thinking and conducting business
> A system that when implemented will bring about continuous improvement
> A structured system which will help you solve customer problems
> Using the collective knowledge and talents of all people in the organization
> Intensified by the use of statistical process controls
> Implemented NOW but will continue forever

What is in it for me?

TQM Benefits

> Reduced customer complaints
  - Increased customer retention
  - Increased customer satisfaction

> Increased ability to attract new customers
  - Increased market share
  - Stay in business

> Increased workforce satisfaction
  - Reduced turnover
  - Provide jobs and more jobs

> Better services from the same dollars
  - Improved productivity
  - Reduction of waste
  - Reduction in rework
  - Reduction in inspection time

51 handouts/overheads

TQM Involving Employees

Training
Teaming
Communicating
Empowering
Recognizing

MFG-J2

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-J2

Subject: **Manufacturing Technology** **Time: 12 Hrs.**

Duty: **Participate in Total Quality and SPC Activities**
Task: Demonstrate Quality Problem Solving Techniques

Objective(s):

Upon completion of this unit the student will be able to:

a. Understand the need in today's fast paced business environment to improve manufacturing processes and efficiency through the diligent use of a problem solving model;
b. Identify the six steps of the six-step problem solving model;
c. Identify each of the sub-steps of the six-step problem solving model;
d. Apply the six-step problem solving model in individual and in team situations within the manufacturing environment;
e. Understand the "Circle of Influence" phenomenon and its impact on successful problem solving in the manufacturing environment; and,
f. Use problem solving tools, e.g., brainstorming, cause and effect diagram, paired choice matrix, and the criteria ranking form.

Instructional Materials:

MASTER Handout (MFG-J2-HO)
Videos "The Step-By-Step Problem Solving" by Richard Chang Associates, Latest Edition
Step-By-Step Problem Solving Trainer's Guide (and accompanying overheads), Chang and Kelly, Richard Chang Associates, Latest Edition
Step-By-Step Problems Solving Participant Workbook, Chang and Kelly, Richard Chang Associates, Latest Edition
Step-By-Step Problem Solving: A Practical Guide to Ensure Problems Get (And Stay) Solved, Chang and Kelly, Richard Chang Associates, Latest Edition (the course textbook)

References:

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-J1 "Discuss TQM in Manufacturing"

Introduction:

Productive employees need to possess strong problem solving skills to remain employed in today's fast-paced, demanding and team intensive global marketplace. Understanding of, and the ability to utilize, effectively the a systematic model for problem solving, such as the "Step-By-Step" model, will greatly enhance an employee's contribution to the industrial workplace of his or her company.

Presentation Outline:

NOTE: Prior to presenting the "Step-By-Step" course, the instructor should review the Instructional Video, Textbook, Participants Workbook, the Trainer's Guide, and the accompanying overheads, and determine how much material can be presented based on the time allowed. Once this determination is made the instructor can use the Trainer's Guide to determine which of the "three options - A, B, or C" will be used, modifying its format to present the appropriate material. ***The Participants Workbook contains eight exercises*** that should be used to supplement the video. Total time to watch the video, cover the overheads, and complete the exercises could be 8-12 hours depending on classes size and participation.

I. Discuss the Need in Today's Fast Paced Business Environment to Improve Manufacturing Processes and Efficiency Through the Diligent Use of a Problem Solving Model
II. Discuss the Six Steps of the Six-Step Problem Solving Model
III. Discuss Each of the Sub-Steps of the Six-Step Problem Solving Model
IV. Discuss the Six-Step Problem Solving Model in Individual and in Team Situations Within the Manufacturing Environment
V. Discuss the "Circle of Influence" Phenomenon and its Impact on Successful Problem Solving in the Manufacturing Environment
VI. Discuss Problem Solving Tools, e.g., Brainstorming, Cause and Effect Diagram, Paired Choice Matrix, and the Criteria Ranking Form

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Practical Application:

Students will view the videos, take notes, participate in discussions and complete the exercises, all of which will bring the students to a mastery of empowerment.

Evaluation and/or Verification:

Successful completion of the module will be based on the student's demonstration of the ability to:

a. Understand the need in today's fast faced business environment to improve manufacturing processes and efficiency through the diligent use of a problem solving model;
b. Identify the six steps of the six-step problem solving model;
c. Identify each of the sub-steps of the six-step problem solving model;
d. Apply the six-step problem solving model in individual and in team situations within the manufacturing environment;
e. Understand the "Circle of Influence" phenomenon and its impact on successful problem solving in the manufacturing environment; and,
f. Use problem solving tools, e.g., brainstorming, cause and effect diagram, paired choice matrix, and the criteria ranking form.

The Self-Assessments for this module are found in the Participant Workbook.

Summary:

Review the main lesson points using the textbook, hold class discussion, and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-J3) dealing with demonstrating knowledge of SPC concepts.

MFG-J2-HO
Demonstrate Quality Problem Solving Techniques
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Understand the need in today's fast paced business environment to improve manufacturing processes and efficiency through the diligent use of a problem solving model;
b. Identify the six steps of the six-step problem solving model;
c. Identify each of the sub-steps of the six-step problem solving model;
d. Apply the six-step problem solving model in individual and in team situations within the manufacturing environment;
e. Understand the "Circle of Influence" phenomenon and its impact on successful problem solving in the manufacturing environment; and,
f. Use problem solving tools, e.g., brainstorming, cause and effect diagram, paired choice matrix, and the criteria ranking form.

Module Outline:

I. Discuss the Need in Today's Fast Paced Business Environment to Improve Manufacturing Processes and Efficiency Through the Diligent Use of a Problem Solving Model
II. Discuss the Six Steps of the Six-Step Problem Solving Model
III. Discuss Each of the Sub-Steps of the Six-Step Problem Solving Model
IV. Discuss the Six-Step Problem Solving Model in Individual and in Team Situations Within the Manufacturing Environment
V. Discuss the "Circle of Influence" Phenomenon and its Impact on Successful Problem Solving in the Manufacturing Environment
VI. Discuss Problem Solving Tools, e.g., Brainstorming, Cause and Effect Diagram, Paired Choice Matrix, and the Criteria Ranking Form

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-J3

Subject: **Manufacturing Technology** **Time: 12 Hrs.**

Duty: **Participate in Total Quality and SPC Activities**
Task: Demonstrate Knowledge of SPC Concepts

Objective(s):

Upon completion of this unit the student will be able to:

a. Understand basic statistic for manufacturing process control;
b. Define variation and probability;
c. Identify the difference between "natural variation" and "unnatural variation";
d. Describe the difference between expected occurrence and actual occurrences of an event;
e. Identify a histogram;
f. Recognize and describe the normal distribution curve;
g. Understand the usefulness of the normal or bell curve to SPC;
h. Explain how the area under the normal curve is divided into standard deviations, or sigma (σ) units;
i. Define and calculate mean and range;
j. Apply a formula to estimate standard deviation;
k. Describe the relationship between the distributions of individuals and sample averages;
l. State the purpose of a control chart;
m. Identify the central line of a control chart;
n. Explain the difference between control limits and engineering specifications or tolerances;
o. Describe why the control chart has so much power;
p. Describe the purpose of a process capability study;
q. Define control chart variables and explain what X "bar" and R charts illustrate about a manufacturing process;
r. Explain the relationship between X "bar" (mean of sample) and R (range) of samples;
s. Define attributes and explain what "p" charts tell about a manufacturing process;
t. Interpret control charts by identifying the patter of points that shows the presence of a normal distribution; and,
u. Recognize the five signs that show a process may be out of control.

Instructional Materials:

MASTER Handout (MFG-J3-HO)
Videos "*No Sweat* Statistic Training Program", Excel Training, Inc., Latest Edition
No Sweat Statistics Training Program: Leader's Guide, Excel Training, Inc., Latest Edition
No Sweat Statistics Training Program: Participants Guide, Excel Training, Inc., Latest Edition

References:

None.

Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-J1	"Discuss TQM in Manufacturing"
MFG-J2	"Demonstrate Quality Problem Solving Techniques"

Introduction:

Productive employees need to possess strong problem solving skills to remain employed in today's fast paced, demanding and team intensive global marketplace. Understanding of, and the ability to utilize effectively, the systematic model for problem solving tools, such as statistical process control, will greatly enhance an employee's contribution to the industrial workplace of his or her company.

Presentation Outline:

NOTE: Prior to presenting the "*No Sweat* Statistics" course, the instructor should review the Instructional Video, Participants Workbook, the Trainer's Guide, and the accompanying overheads and also determine how much material can be presented based on the time allowed. ***The Participants Workbook contains numerous exercises*** that should be used to supplement the video. Total time to watch the video, cover the overheads, and complete the exercises could be 8-12 hours, depending on classes size and participation.

I. Discuss Basic Statistic for Manufacturing Process Control
II. Discuss Variation and Probability
III. Discuss the Difference Between "Natural Variation" and "Unnatural Variation"

IV. Discuss the Difference Between Expected Occurrence and Actual Occurrences of an Event
V. Discuss a Histogram
VI. Discuss and Describe the Normal Distribution Curve
VII. Discuss the Usefulness of the Normal or Bell Curve to SPC
VIII. Discuss How the Area under the Normal Curve Is Divided into Standard Deviations, or Sigma (Σ) Units
IX. Discuss and Calculate Mean and Range
X. Discuss a Formula to Estimate Standard Deviation
XI. Discuss the Relationship Between the Distributions of Individuals and Sample Averages
XII. Discuss the Purpose of a Control Chart
XIII. Discuss the Central Line of a Control Chart
XIV. Discuss the Difference Between Control Limits and Engineering Specifications or Tolerances
XV. Discuss Why the Control Chart Has So Much Power
XVI. Discuss the Purpose of a Process Capability Study
XVII. Discuss Control Chart Variables and Explain What X "Bar" and R Charts Illustrate about a Manufacturing Process
XVIII. Discuss the Relationship Between X "Bar" (Mean of Sample) and R (Range) of Samples
XIX. Discuss Attributes and Explain What P Charts Tell about a Manufacturing Process
XX. Discuss Control Charts by Identifying the Patter of Points That Shows the Presence of a Normal Distribution
XXI. Discuss the Five Signs That Show a Process May Be out of Control

Practical Application:

Students will view the videos, take notes, participate in discussions and complete the self-assessment, all of which will bring the students to a mastery of Statistical Process Control concepts.

Evaluation and/or Verification:

Successful completion of the module will be based on the student's demonstration of the ability to:

a. Understand basic statistic for manufacturing process control;
b. Define variation and probability;
c. Identify the difference between “natural variation” and “unnatural variation”;
d. Describe the difference between expected occurrence and actual occurrences of an event;
e. Identify a histogram;

f. Recognize and describe the normal distribution curve;
g. Understand the usefulness of the normal or bell curve to SPC;
h. Explain how the area under the normal curve is divided into standard deviations, or sigma (σ) units;
i. Define and calculate mean and range;
j. Apply a formula to estimate standard deviation;
k. Describe the relationship between the distributions of individuals and sample averages;
l. State the purpose of a control chart;
m. Identify the central line of a control chart;
n. Explain the difference between control limits and engineering specifications or tolerances;
o. Describe why the control chart has so much power;
p. Describe the purpose of a process capability study;
q. Define control chart variables and explain what X "bar" and R charts illustrate about a manufacturing process;
r. Explain the relationship between X "bar" (mean of sample) and R (range) of samples;
s. Define attributes and explain what "p" charts tell about a manufacturing process;
t. Interpret control charts by identifying the patter of points that shows the presence of a normal distribution; and,
u. Recognize the five signs that show a process may be out of control.

The Self-Assessments for this module are found in the Participants Guide.

Summary:

Review the main lesson points using the textbook, hold class discussion and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-K1) dealing with recognition of electrical components.

MFG-J3-HO
Demonstrate Knowledge of SPC Concepts
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Understand basic statistic for manufacturing process control;
b. Define variation and probability;
c. Identify the difference between "natural variation" and "unnatural variation";
d. Describe the difference between expected occurrence and actual occurrences of an event;
e. Identify a histogram;
f. Recognize and describe the normal distribution curve;
g. Understand the usefulness of the normal or bell curve to SPC;
h. Explain how the area under the normal curve is divided into standard deviations, or sigma (σ) units;
i. Define and calculate mean and range;
j. Apply a formula to estimate standard deviation;
k. Describe the relationship between the distributions of individuals and sample averages;
l. State the purpose of a control chart;
m. Identify the central line of a control chart;
n. Explain the difference between control limits and engineering specifications or tolerances;
o. Describe why the control chart has so much power;
p. Describe the purpose of a process capability study;
q. Define control chart variables and explain what X "bar" and R charts illustrate about a manufacturing process;
r. Explain the relationship between X "bar" (mean of sample) and R (range) of samples;
s. Define attributes and explain what "p" charts tell about a manufacturing process;
t. Interpret control charts by identifying the patter of points that shows the presence of a normal distribution; and,
u. Recognize the five signs that show a process may be out of control.

Module Outline:

I. Discuss Basic Statistic for Manufacturing Process Control
II. Discuss Variation and Probability

III. Discuss the Difference Between “Natural Variation” and “Unnatural Variation”
IV. Discuss the Difference Between Expected Occurrence and Actual Occurrences of an Event
V. Discuss a Histogram
VI. Discuss and Describe the Normal Distribution Curve
VII. Discuss the Usefulness of the Normal or Bell Curve to SPC
VIII. Discuss How the Area under the Normal Curve Is Divided into Standard Deviations, or Sigma (Σ) Units
IX. Discuss and Calculate Mean and Range
X. Discuss a Formula to Estimate Standard Deviation
XI. Discuss the Relationship Between the Distributions of Individuals and Sample Averages
XII. Discuss the Purpose of a Control Chart
XIII. Discuss the Central Line of a Control Chart
XIV. Discuss the Difference Between Control Limits and Engineering Specifications or Tolerances
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XIX. Discuss Attributes and Explain What P Charts Tell about a Manufacturing Process
XX. Discuss Control Charts by Identifying the Patter of Points That Shows the Presence of a Normal Distribution
XXI. Discuss the Five Signs That Show a Process May Be out of Control

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

Duty K

MFG-K1

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-K1

Subject: Manufacturing Technology **Time: 40 Hrs.**

Duty: Maintain Electrical Devices
Task: Recognize Electrical Components

Objective(s):

Upon completion of this module the student will be able to:

1. Recognize the various components of electrical power systems;
2. Recognize and control hazards unique to electrical systems; and,
3. Use electrical tables to compute system demands and loads.

Instructional Materials:

MASTER Handout (MFG-K1-HO)
MASTER Laboratory Worksheet (MFG-K1-LW)
MASTER Self-Assessment
Assorted circuit breakers
Assorted fuses
Examples of wires and connectors
Relays
Assorted switches
Starting capacitors
Solenoids
Breaker panel mock-up

References:

National Electrical Code, National Fire Safety Board, Latest Edition

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Student Preparation:

Students should have previously completed the following technical modules:

MFG-A1 through MFG-A7	"Practice Safety"
MFG-B1	"Perform Basic Arithmetic Functions"
MFG-B2	"Convert Fractions/Decimals"
MFG-B3	"Convert Metric/English Measurements"
MFG-B4	"Use Practical Geometry"
MFG-C1	"Identify Basic Layout of Drawings"
MFG-C2	"Identify Basic Types of Drawings"

MFG-C3 "Review Blueprint Notes and Dimensions"
MFG-C4 "List the Purpose of Each Type of Drawing"
MFG-C5 "Verify Drawing Elements"
MFG-F2 "Use Hand Tools"

Introduction:

In the modern factory, nothing moves without electricity. The power of the electron turns lathes, provides light, moves loads, and does innumerable other things. One of the most important functions of the manufacturing technician is ensuring that those tiny electrons continue to flow properly.

Presentation Outline:

- I. Electrical Annotations and Symbols in Blueprints
- II. Electrical Components
  - A. Terminology
    - 1. Volt
    - 2. Ampere
    - 3. Ohm
    - 4. AC vs DC
    - 5. Watt
  - B. Wire
    - 1. Sizes
      - a. AWG and KCIL
      - b. Relationship of size to ampacity
    - 2. Types of coverings
      - a. THHN and its kin
      - b. XHHW and its kin
      - c. NMB vs UFB
      - d. SJO and SJOW
      - e. Other types
    - 3. Aluminum vs Copper
    - 4. Cupro-nickel internal wiring
    - 5. Co-axial cable
  - C. Circuit breakers
    - 1. Sizes
    - 2. Voltage ratings
    - 3. Poles
    - 4. Three-phase
  - D. Fuses
    - 1. Types
      - a. Cartridge types
      - b. Edison or large-base plug fuses

      - c. Small-base plug fuses
      - d. Adaptors for fuse types
    - 2. Time delay vs. fast blowing
    - 3. Reading Edison and small-base fuses to determine overload or short circuit
  - E. Boxes
    - 1. Sizes
    - 2. Composition (PVC, Metal)
    - 3. Counting wires in a box
  - F. Tubing
    - 1. Sizes
    - 2. Composition (PVC, EMT, Rigid)
    - 3. BX and shielded cable
    - 4. Connectors and corners
      - a. Tube to tube
      - b. Mounting for tubes
      - c. Tube to box
      - d. Tees, elbows, and sweeps
  - G. Switches
    - 1. Poles and throws
    - 2. Two-way, three-way, and four-way
    - 3. A/B switches
  - H. Receptacles
    - 1. Small-faced configurations
    - 2. Large-faced configurations
    - 3. Tine patterns and ratings
  - I. Motor controls
    - 1. Relays
    - 2. Starting capacitors
    - 3. Surge considerations
    - 4. Three-phase controls
- III. Electrical Hazards
  - A. Protective clothing
  - B. Insulated tools
  - C. Amperes can kill!
  - D. Testing live wires
- IV. Using the NEC Tables
  - A. Determination of voltage drop
  - B. Maximum ampacity tables
  - C. Common horsepower tables
  - D. Other tables

Practical Application:

Students will demonstrate familiarity with the tables in the NEC and will identify various components as determined by the instructor.

Evaluation and Verification:

Students will successfully complete the Self-Assessment found at the end of this lesson by scoring a minimum of 90%.

Summary:

The instructor will review the main lesson points and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-K2) dealing with the use of electrical testing devices.

MFG-K1-HO
Recognize Electrical Components
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to:

1. Recognize the various components of electrical power systems;
2. Recognize and control hazards unique to electrical systems; and,
3. Use electrical tables to compute system demands and loads.

Module Outline:

- I. Electrical Annotations and Symbols in Blueprints
- II. Electrical Components
  - A. Terminology
    - 1. Volt
    - 2. Ampere
    - 3. Ohm
    - 4. AC vs DC
    - 5. Watt
  - B. Wire
    - 1. Sizes
      - a. AWG and KCIL
      - b. Relationship of size to ampacity
    - 2. Types of coverings
      - a. THHN and its kin
      - b. XHHW and its kin
      - c. NMB vs UFB
      - d. SJO and SJOW
      - e. Other types
    - 3. Aluminum vs Copper
    - 4. Cupro-nickel internal wiring
    - 5. Co-axial cable
  - C. Circuit breakers
    - 1. Sizes
    - 2. Voltage ratings
    - 3. Poles
    - 4. Three-phase
  - D. Fuses
    - 1. Types
      - a. Cartridge types
      - b. Edison or large-base plug fuses
      - c. Small-base plug fuses

        d. Adaptors for fuse types
    2. Time delay vs. fast blowing
    3. Reading Edison and small-base fuses to determine overload or short circuit
  E. Boxes
    1. Sizes
    2. Composition (PVC, Metal)
    3. Counting wires in a box
  F. Tubing
    1. Sizes
    2. Composition (PVC, EMT, Rigid)
    3. BX and shielded cable
    4. Connectors and corners
        a. Tube to tube
        b. Mounting for tubes
        c. Tube to box
        d. Tees, elbows, and sweeps
  G. Switches
    1. Poles and throws
    2. Two-way, three-way, and four-way
    3. A/B switches
  H. Receptacles
    1. Small-faced configurations
    2. Large-faced configurations
    3. Tine patterns and ratings
  I. Motor controls
    1. Relays
    2. Starting capacitors
    3. Surge considerations
    4. Three-phase controls
III. Electrical Hazards
  A. Protective clothing
  B. Insulated tools
  C. Amperes can kill!
  D. Testing live wires
IV. Using the NEC Tables
  A. Determination of voltage drop
  B. Maximum ampacity tables
  C. Common horsepower tables
  D. Other tables

MFG-K1-LW
Recognize Electrical Components
Attachment 2: MASTER Laboratory Worksheet

I. The instructor should take the students on a tour of the facility. This tour should focus on the electrical power controls of the buildings.

II. Taking the circuits from the Self-Assessment Answer Key, Questions 9 and 10, the students will set up the mock-up breaker panel.

III. The students will calculate the total load of the mock-up panel and determine the appropriate size of the panel's main breaker.

IV. The instructor may demonstrate the differences in blown fuses, and distribute some of them amongst the students for identification. This section is optional.

Name:______________________ Date:______________________

MFG-K1
Recognize Electrical Components
Self-Assessment

Circle the letter preceding the best answer to the following questions.

1. Technician A says that copper 2/0 electrical wire has more ampacity than does 2/0 aluminum wire. Technician B says that 3/0 aluminum wire has approximately the same ampacity as 2/0 copper wire. Who is correct?
   A. Technician A only
   B. Technician B only
   C. Both technicians are correct.
   D. Neither technician is correct.

2. Single-pole, single-throw switches:
   A. Require that only one leg of the circuit be broken.
   B. Are wired in series with the device(s) which they control.
   C. Can only turn devices ON or OFF.
   D. All of the above answers are correct.
   E. None of the above answers is correct.

3. The minimum acceptable wire size for a thirty ampere circuit is:
   A. 14 AWG.
   B. 12 AWG.
   C. 10 AWG.
   D. 8 AWG.
   E. None of the above answers is correct.

4. Technician A says that a fuse usually blows in one of two ways: either the circuit is overloaded, or it has a short. Technician B says that Edison fuses can be examined and indicate which cause resulted in the blown fuse. Who is correct?
   A. Technician A only
   B. Technician B only
   C. Both technicians are correct.
   D. Neither technician is correct.

5. When changing circuit breakers in the panel, the technician should:
   A. Make sure that all power to the panel is OFF.
   B. Replace the breaker only with an *identical* breaker.
   C. First disconnect the ground wire from its bus.
   D. All of the above steps must be taken.
   E. None of the above answers is correct.

6. The NEC requires that true grounding wires (as opposed to grounded neutral wires) be:
   A. In green jackets.
   B. In white jackets.
   C. Bare.
   D. Either A or C.
   E. Either B or C.

7. Technician A says that the 12V AC power supplied by each reserve battery of a generator must be supplied in series in order to start and to operate the generator. Technician B says that both battery-powered and gasoline-powered generators produce AC current. Who is correct?
   A. Technician A only
   B. Technician B only
   C. Both technicians are correct.
   D. Neither technician is correct.

8. Which of the following is **not** correctly set up?
   A. A 20A fuse on a 12 AWG wire.
   B. A 50A circuit breaker on a 10AWG wire.
   C. A 2000 W constant load on a 20A circuit breaker.
   D. All of the above circuits are correctly set up.
   E. None of the above answers is correct.

9. Calculate the amperages of the following circuits:
   A. 1200 W at 120 V
   B. 6000 W at 240 V
   C. 10,000 W at 240 V
   D. 8000 W at 120 V
   E. 12,000 W at 120 V

10. Presuming copper wire and minimal distances, what sizes of wire are required for the five circuits in Question 9?

A. ______________________

B. ______________________

C. ______________________

D. ______________________

E. ______________________

MFG-K1
Recognize Electrical Components
Self-Assessment Answer Key

1.	C	
2.	D	
3.	C	
4.	C	
5.	A	
6.	D	
7.	B	
8.	B	
9.	A.	10
	B.	25
	C.	42 (rounded)
	D.	67 (rounded)
	E.	100
10.	A.	12
	B.	10
	C.	8
	D.	4
	E.	2 (Not 2/0)

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-K2

Subject: **Manufacturing Technology** **Time: 20 Hrs.**

Duty: **Maintain Electrical Devices**
Task: Use Electrical Test Equipment

Objective(s):

Upon completion of this module the student will be able to:

a. Properly use electrical test equipment;
b. Measure ohms;
c. Measure DC volts;
d. Measure AC volts; and,
e. Measure DC amps.

Instructional Materials:

MASTER Handout (MFG-K2-HO)
MASTER Laboratory Worksheet (MFG-K2-LW)
MASTER Laboratory Aid (MFG-K2-LA)
MASTER Self-Assessment
VOM-Analog
VOM-Digital

References:

Basic Electronics, Bernard Grob, McGraw-Hill Publishers, Latest Edition
Electrical and Basic Electronics, Matt, Goodheart-Willcox Publishers, Latest Edition
Exploring Electricity/Electronics, Delmar Publishers, Latest Edition

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Student Preparation:

Students should have previously completed the following Technical Modules:

MFG-A1 through MFG-A7 "Practice Safety"
MFG-K1 "Recognize Electrical Components"

Introduction:

Working safely should be the concern of every individual. Safety includes protecting yourself and others from injury. While others - your employer, your family,

governmental agencies, and insurance companies are concerned for your well-being, you have the final responsibility for your safety in the workplace. Being aware of your surrounding and selecting and using correct safety equipment is your responsibility.

Presentation Outline:

I. DC Voltage Measurement
II. AC Voltage Measurement
III. DC Current Measurement
IV. Resistance Measurement

Practical Application:

1. Instructor will demonstrate selection and proper use of electrical test equipment.

2. Students will be allowed to practice the use of electrical test equipment.

Evaluation and/or Verification:

Successful completion of this technical module will be based on the student's successful completion of the written and practical evaluation.

Summary:

Review the main lesson points using the objectives as a guide for discussion and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-K3) dealing with troubleshooting electrical devices.

MFG-K2-HO
Use Electrical Test Equipment
Attachment 1: MASTER Handout

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

Objective(s):

Upon completion of this module the student will be able to:

a. Properly use electrical test equipment;
b. Measure ohms;
c. Measure DC volts;
d. Measure AC volts; and,
e. Measure DC amps.

Reading Assignments:

The following chapters are assigned to read from *Electricity I*, Kubala, Delmar Publishing, Latest Edition:

Chapter	Title
6	Circuits

Module Outline:

I. DC Voltage Measurement
II. AC Voltage Measurement
III. DC Current Measurement
IV. Resistance Measurement

MFG-K2-LA
Use Electrical Test Equipment
Attachment 2: MASTER Laboratory Aid

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

MFG-K2-LW
Use Electrical Test Equipment
Attachment 3: **MASTER** Laboratory Worksheet

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1. Student will practice performing:
    a. DC voltage measurement;
    b. AC voltage measurement;
    c. DC current measurement; and,
    d. Resistance measurement.

2. Instructor will grade student's performance on:
    a. DC voltage measurement;
    b. AC voltage measurement;
    c. DC current measurement; and,
    d. Resistance measurement.

Name:______________________ Date:______________________

MFG-K2
Use Electrical Test Equipment
Self-Assessment

1. Describe how to use an analog multimeter to measure DC voltage.

2. Describe how to use an analog multimeter to measure AC voltage.

3. Describe how to use an analog multimeter to measure DC current.

4. Describe how to use an analog multimeter to measure resistant.

5. Describe how to use an digital multimeter to measure DC voltage.

6. Describe how to use an digital multimeter to measure AC voltage.

7. Describe how to use an digital multimeter to measure DC current.

8. Describe how to use an digital multimeter to measure resistant.

MANUFACTURING TECHNOLOGY SERIES
MASTER Technical Module No. MFG-K3

Subject: **Manufacturing Technology** **Time: 10 Hrs.**

Duty: **Maintain Electrical Devices**
Task: Troubleshoot Electrical Devices

Objective(s):

Upon completion of this module the student will be able to troubleshoot the following devices:

a. Resistors;
b. Capacitors;
c. Inductors;
d. Motors; and,
e. Relays.

Instructional Materials:

MASTER Handout (MFG-K3-HO)
MASTER Laboratory Worksheet (MFG-K3-LW)
MASTER Laboratory Aid (MFG-K3-LA)
MASTER Self-Assessment
Resistor
Capacitors
Inductors
Motors
Relays

References:

Instrumentation, Kirk, ATP Publishers, Latest Edition
Automated Process Control Electronics, Harrington, Delmar Publishers, Latest Edition
Electrical and Basic Electronics, Matt, Goodheart-Willcox Publishers, Latest Edition
Exploring Electricity/Electronics, Delmar Publishers, Latest Edition

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Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-A1 through MFG-A7 "Practice Safety"

MFG-K1 "Recognize Electrical Components"
MFG-K2 "Use Electrical Test Equipment"

Introduction:

Troubleshooting is the skill of solving an electrical problem and fixing the problem. This skill is in high demand today.

Presentation Outline:

I. Resistors
II. Capacitors
III. Inductors
IV. Motors
V. Relays

Practical Application:

Student will practice troubleshooting electrical devices.

Evaluation and/or Verification:

Successful completion of this technical module will be based on the student's successful completion of the Self-Assessment.

Summary:

Review the main lesson points using the objectives as a guide for discussion and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-L1) dealing with troubleshooting, maintaining, and repairing hydraulic systems.

MFG-K3-HO
Troubleshoot Electrical Devices
Attachment 1: **MASTER** Handout

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

Objective(s):

Upon completion of this module the student will be able to troubleshoot the following devices:

a. Resistors;
b. Capacitors;
c. Inductors;
d. Motors; and,
e. Relays.

Reading Assignments:

The following chapters are assigned to read from *Basic Electronics,* Grob, McGraw-Hill Publishers, Latest Edition:

Chapters	Title
17	Capacitance
20	Inductance

Module Outline:

I. Resistors
II. Capacitors
III. Inductors
IV. Motors
V. Relays

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

MFG-K3-LW
Troubleshoot Electrical Devices
Attachment 3: MASTER Laboratory Worksheet

---

1. Student will practice troubleshooting:
   - a. Resistors;
   - b. Capacitors;
   - c. Inductors;
   - d. Motors; and,
   - e. Relays.

2. Instructor will grade students performance on troubleshooting:
   - a. Resistors;
   - b. Capacitors;
   - c. Inductors;
   - d. Motors; and,
   - e. Relays.

Name:____________________ Date:____________________

MFG-K3
Troubleshoot Electrical Devices
Self-Assessment

1. Define troubleshooting.

2. List logical steps to troubleshooting an electrical service.

3. What does a resistor do in an electrical circuit?

4. What is the normal function for a capacitor?

5. What is the normal function for an inductor?

6. What is the normal function for a relay?

7. List major types of DC, Single phase AC and three phase.

8. For problem #7 list major characteristic of each.

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MFG PMS
01/2000

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-L1

Subject: **Manufacturing Technology** **Time: 40 Hrs.**

Duty: **Maintain Hydraulic/Pneumatic Devices**
Task: Troubleshoot, Maintain, and Repair Hydraulic Systems

Objective(s):

Upon completion of this module the student will be able to:

a. Troubleshoot hydraulic system;
b. Maintain hydraulic system; and,
c. Repair hydraulic system.

Instructional Materials:

MASTER Handout (MFG-L1-HO)
MASTER Laboratory Worksheet (MFG-L1-LW)
MASTER Laboratory Aid (MFG-L1-LA)
MASTER Self-Assessment
Hydraulic trainer

References:

ABCs of Hydraulic Circuits, Harry Stewart, Sams Company, Latest Edition
Handbook of Hydraulics, Horace Williams, McGraw-Hill Publishers, Latest Edition
Hydraulic Systems Analysis, John Stringer, Wiley Co., Latest Edition
Flow Control, William S. Buzzard, ISA Publishers, Latest Edition
Davis' Handbook of Applied Hydraulics, Vincent Zipparro, McGraw-Hill Publishers, Latest Edition
Mechanics of Fluids, Herman Shames, McGraw-Hill Publishers, Latest Edition
Fluid Power and Control Systems, Ernest Fitch, Jr., McGraw-Hill Publishers, Latest Edition

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-A1 through MFG-A7 "Practice Safety"

Introduction:

With hydraulic power, one is able to move large objects. Hydraulic power is large but moves slow. Hydraulic power moves large loads in industry.

Presentation Outline:

I. Hydraulic Theory
II. Storage Devices
III. Pumps-Prime Movers
IV. Actuators
V. Control Devices
VI. Accumulators

Practical Application:

1. Instructors will demonstrate how to troubleshoot, maintain and repair hydraulic systems.
2. Student will demonstrate how to troubleshoot, maintain and repair hydraulic systems.

Evaluation and/or Verification:

Successful completion of this technical module will be based on the student's successful completion of the written evaluation.

Summary:

Review the main lesson points using the objectives as a guide for discussion and answer student questions.

Next Lesson Assignment:

MASTER Technical Module (MFG-L2) dealing with troubleshooting, maintaining, and repairing pneumatic systems.

MFG-L1-HO
Troubleshoot, Maintain, and Repair Hydraulic Systems
Attachment 1: MASTER Handout

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

Objectives:

Upon completion of this module the student will be able to:

a. Troubleshoot hydraulic system;
b. Maintain hydraulic system; and
c. Repair hydraulic system.

Reading Assignments:

The following chapters are assigned to read from *Fluid Power 1*, by Parker Publishers, Latest Edition:

Chapter	Title
3	Energy Transmission Using a Hydraulic System
4	Control of Hydraulic Energy
7	Hydraulic Pumps
8	Check Valves, Cylinders and Motors
10	Directional Control Valves
12	Pilot Operated Pressure Control Valves

Module Outline:

I. Hydraulic Theory
II. Storage Devices
III. Pumps-Prime Movers
IV. Actuators
V. Control Devices
VI. Accumulators

MFG-L1-LA
Troubleshoot, Maintain, and Repair Hydraulic Systems
Attachment 2: MASTER Laboratory Aid

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

MFG-L1-LW
Troubleshoot, Maintain, and Repair Hydraulic Systems
Attachment 3: MASTER Laboratory Worksheet

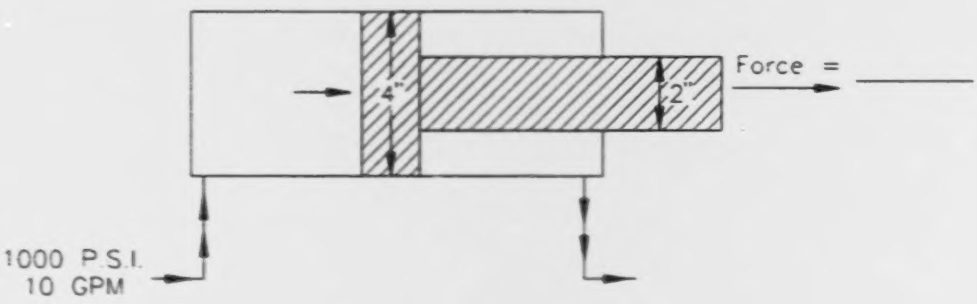
Worksheet:

1. Student will practice:
   a. Troubleshooting hydraulic system;
   b. Maintaining hydraulic system; and,
   c. Repairing hydraulic system.

2. Instructor will grade student's performance.

Name:______________________ Date:____________________

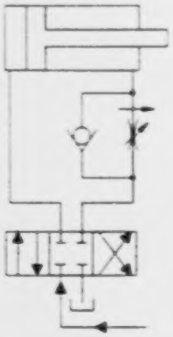
MFG-L1
Troubleshoot, Maintain, and Repair Hydraulic Systems
Self-Assessment



1. In the above diagram, what is the force generated (disregard friction)?
   - A. 14560 lbs
   - B. 13560 lbs
   - C. 12560 lbs
   - D. 11560 lbs

2. At what speed is the cylinder moving?
   - A. 184 inches per minute
   - B. 17 feet per minute
   - C. Either A or B
   - D. Neither A or B

3. This diagram shows a:
   - A. Unworkable circuit.
   - B. Meter-in circuit.
   - C. Meter-in, meter-out circuit.
   - D. Meter-out circuit.



. A system malfunction has been traced to a bad pump. In addition to replacing the pump, one should also:
A. Replace the relief valve.
B. Adjust the main control valve.
C. Adjust the cylinder packing.
D. Find out what caused the pump to fail.

5. Cavitation occurs in a pump when:
A. The fluid does not completely fill the space provided for it in the pump.
B. The pressure from the output causes the pump to cease pumping action.
C. The flow from the pump cannot be increased by increasing the RPM.
D. The inlet is too large, allowing too much oil to the pump.

MFG-L2

MANUFACTURING TECHNOLOGY SERIES

MASTER Technical Module No. MFG-L2

Subject: **Maufacturing Technology** **Time: 40 Hrs.**

Duty: **Maintain Hydraulic/Pneumatic Devices**
Task: Troubleshoot, Maintain, and Repair Pneumatic Systems

Objective(s):

Upon completion of this module the student will be able to:
a. Maintain pneumatic system;
b. Troubleshoot pneumatic system; and,
c. Repair pneumatic system.

Instructional Materials:

MASTER Handout (MFG-L2-HO)
MASTER Laboratory Worksheet (MFG-L2-LW)
MASTER Laboratory Aid (MFG-L2-LA)
MASTER Self-Assessment
Directional control valves
Relief valve
Tubing
Compressor

References:

Fluid Power, Parker Publishing, Latest Edition
Industrial Pneumatic Technology, Parker Publishing, Latest Edition

Student Preparation:

Students should have previously completed the following Technical Modules:
MFG-A1 through MFG-A7 "Practice Safety"

Introduction:

Pneumatic systems are used to control HVAC systems, cleaning, cutting, turning, mixing, moving and many other industrial and business application.

Presentation Outline:

I. Pneumatic Theory
II. Compressor
III. Regulators
IV. Valves
V. Actuators
VI. Safety
VII. Prevention Maintenance
VIII. Troubleshooting Pneumatic Devices
IX. Repair Pneumatic Devices

Practical Application:

Student will practice with a working pneumatic system.

Evaluation and/or Verification:

Successful completion of this technical module will be based on the student's successful completion of the written evaluation.

Summary:

Review the main lesson points using the objectives as a guide for discussion and answer student questions.

Next Lesson Assignment:

MFG-L2-HO

Troubleshoot, Maintain, and Repair Pneumatic Systems

Attachment 1: MASTER Handout

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

Objectives:

Upon completion of this module the student will be able to:

a. Maintain pneumatic system;
b. Troubleshoot pneumatic system; and,
c. Repair pneumatic system.

Reading Assignments:

The following chapters are assigned to read from *Fluid Power 1,* by Parker Publisher, Latest Edition:

Chapters	Title
5	Energy Transmission Using A Pneumatic System
11	Simple Pressure Control Valves

Module Outline:

I. Pneumatic Theory
II. Compressor
III. Regulators
IV. Valves
V. Actuators
VI. Safety
VII. Prevention Maintenance
VIII. Troubleshooting Pneumatic Devices
IX. Repair Pneumatic Devices

MFG-L2-LA
Troubleshoot, Maintain, and Repair Pneumatic Systems
Attachment 2: MASTER Laboratory Aid

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

MFG-L2-LW
Troubleshoot, Maintain, and Repair Pneumatic Systems
Attachment 3: MASTER Laboratory Worksheet

Worksheet:

1. Draw a circuit utilizing a single acting cylinder, gravity return, as the load. Use a directional control valve. Make the cylinder extend. Have the instructor approve the diagram. Construct the circuit. Have the instructor approve the circuit. Run the circuit.

2. Same as Problem #1, except use double acting cylinder.

3. Practice PM on an existing pneumatic system.. Instructor will go over typical PM procedures.

4. Same as Problem #1, except use meter-out circuit.

5. Same as Problem #1, except use a quick exhaust circuit.

Name:____________________________ Date:_______________________

MFG-L2
Troubleshoot, Maintain, and Repair Pneumatic Systems
Self-Assessment

Circle the letter preceding the correct answer.

1. If a force exerted by a piston of 9 in.^{2} area is 2430 pounds, the pressure on the piston is ___________ pounds per square inch.
    a. 2430
    b. 1215
    c. 270
    d. 30

2. Which of the following elements is basic to a complete pneumatic system?
    a. Filters
    b. Tank Storage and Conditioning Equipment
    c. Pressure Gauges
    d. Thermal Sensors

3. The first step in troubleshooting a problem in a pneumatic system is to _________:
    a. Check the fluid level in the reservoir.
    b. List the symptoms.
    c. Study the system's recent history.
    d. Shut down the malfunctioning equipment.

4. The first item to check when you are troubleshooting a pneumatic system is the ________________.
    a. Machine's production rate.
    b. Time of the last overhaul.
    c. Operator's opinion.
    d. Supply air pressure.

5. Which of the following should be checked if a control valve is inoperative? (pneumatics)
    a. Exhaust Muffler
    b. Pilot Pressure
    c. Valve Actuator
    d. All of the above.

6. If a water-cooled compressor has a closed system, it means _______________.
   a. The water is recirculated.
   b. The compressor is sealed as a unit.
   c. The compressor requires no external cooling.
   d. The compressor must be operated indoors.

7. How is the cylinder of a single-acting, air-oil system returned to its starting position?
   a. Gravity
   b. External Load
   c. Return Air-Oil Pressure
   d. Gravity or External Load

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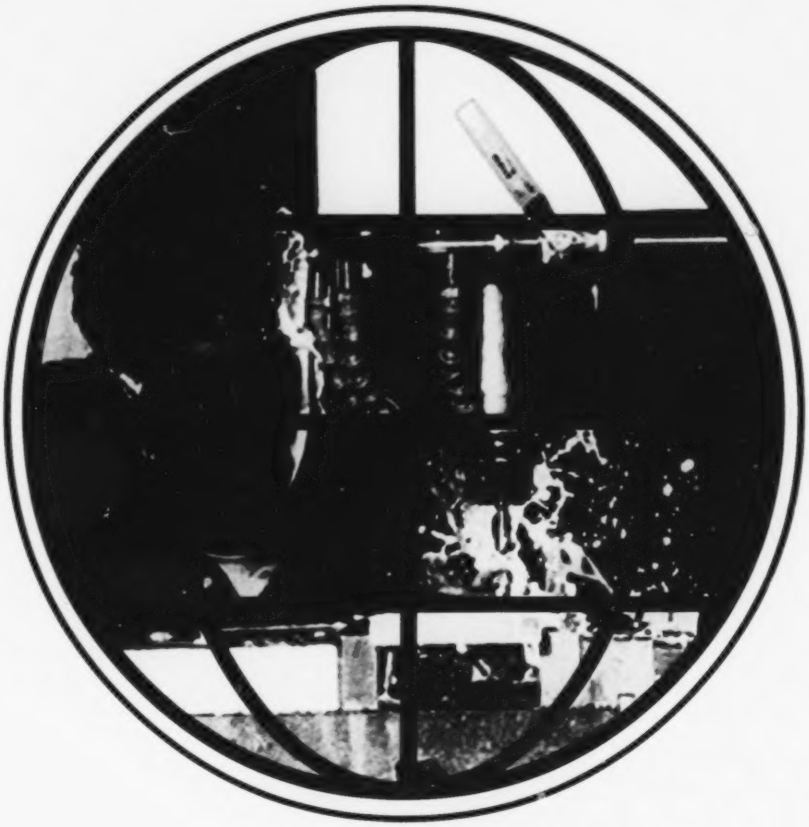

Manufacturing Technology Series
STUDENT LABORATORY MANUAL

Supported by the National Science Foundation's Advanced Technological Education Program

MACHINE TOOL ADVANCED SKILLS TECHNOLOGY EDUCATIONAL RESOURCES

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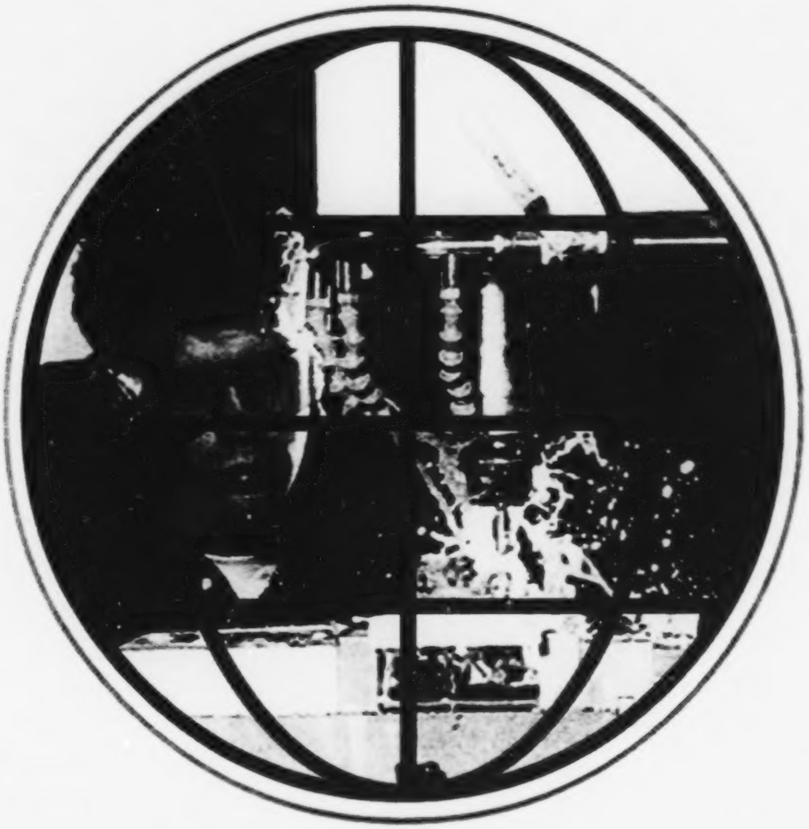
EDUCATIONAL RESOURCES
FOR THE
MACHINE TOOL INDUSTRY



Manufacturing Technology Series
STUDENT LABORATORY MANUAL

Supported by the National Science Foundation's Advanced Technological Education Program

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National Science Foundation
Advanced Technological
Education Program

"Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Foundation."

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National Science Foundation - Division of Undergraduate Education
MASTER Consortia of Employers and Educators

MASTER has built upon the foundation which was laid by the Machine Tool Advanced Skills Technology (MAST) Program. The MAST Program was supported by the U.S. Department of Education - Office of Vocational and Adult Education. Without this prior support MASTER could not have reached the level of quality and quantity that is contained in these project deliverables.

MASTER DEVELOPMENT CENTERS

Augusta Technical Institute - Central Florida Community College - Itawamba Community College - Moraine Valley Community College - San Diego City College (CACT) - Springfield Technical Community College - Texas State Technical College

INDUSTRIES

AB Lasers - AIRCAP/MTD - ALCOA - American Saw - AMOCO Performance Products - Automatic Switch Company - Bell Helicopter - Bowen Tool - Brunner - Chrysler Corp. - Chrysler Technologies - Conveyor Plus - Darr Caterpillar - Davis Technologies - Delta International - Devon - D. J. Plastics - Eaton Leonard - EBTEC - Electro-Motive - Emergency One - Eureka - Foster Mold - GeoDiamond/Smith International - Greenfield Industries - Hunter Douglas - Industrial Laser - ITT Engineered Valve - Kaiser Aluminum - Krueger International. - Laser Fare - Laser Services - Lockheed Martin - McDonnell Douglas - Mercury Tool - NASSCO - NutraSweet - Rapistan DEMAG - Reed Tool - ROHR, International - Searle - Solar Turbine - Southwest Fabricators - Smith & Wesson - Standard Refrigeration - Super Sagless - Taylor Guitars - Tecumseh - Teledyne Ryan - Thermal Ceramics - Thomas Lighting - FMC, United Defense - United Technologies Hamilton Standard

COLLEGE AFFILIATES

Aiken Technical College - Bevil Center for Advanced Manufacturing Technology - Chicago Manufacturing Technology Extension Center - Great Lakes Manufacturing Technology Center - Indiana Vocational Technical College - Milwaukee Area Technical College - Okaloosa-Walton Community College - Piedmont Technical College - Pueblo Community College - Salt Lake Community College - Spokane Community College - Texas State Technical Colleges at Harlington, Marshall, Sweetwater

FEDERAL LABS

Jet Propulsion Lab - Lawrence Livermore National Laboratory - L.B.J. Space Center (NASA) - Los Alamos Laboratory - Oak Ridge National Laboratory - Sandia National Laboratory - Several National Institute of Standards and Technology Centers (NIST) - Tank Automotive Research and Development Center (TARDEC) - Wright Laboratories

SECONDARY SCHOOLS

Aiken Career Center - Chicopee Comprehensive High School - Community High School (Moraine, IL) - Connally ISD - Consolidated High School - Evans High - Greenwood Vocational School - Hoover Sr. High - Killeen ISD - LaVega ISD - Lincoln Sr. High - Marlin ISD - Midway ISD - Moraine Area Career Center - Morse Sr. High - Point Lamar Sr. High -

Pontotoc Ridge Area Vocational Center - Putnam Vocational High School - San Diego Sr. High - Tupelo-Lee Vocational Center - Waco ISD - Westfield Vocational High School

ASSOCIATIONS

American Vocational Association (AVA) - Center for Occupational Research and Development (CORD) - CIM in Higher Education (CIMHE) - Heart of Texas Tech-Prep - Midwest (Michigan) Manufacturing Technology Center (MMTC) - National Coalition For Advanced Manufacturing (NACFAM) - National Coalition of Advanced Technology Centers (NCATC) - National Skills Standards Pilot Programs - National Tooling and Machining Association (NTMA) - New York Manufacturing Extension Partnership (NYMEP) - Precision Metalforming Association (PMA) - Society of Manufacturing Engineers (SME) - Southeast Manufacturing Technology Center (SMTC)

MASTER PROJECT EVALUATORS

Dr. James Hales, East Tennessee State University and William Ruxton, formerly with the National Tooling and Machine Association (NTMA)

NATIONAL ADVISORY COUNCIL MEMBERS

The National Advisory Council has provided input and guidance into the project since the beginning. Without their contributions, MASTER could not have been nearly as successful as it has been. Much appreciation and thanks go to each of the members of this committee from the project team.

Dr. Hugh Rogers-Dean of Technology-Central Florida Community College
Dr. Don Clark-Professor Emeritus-Texas A&M University
Dr. Don Edwards-Department of Management-Baylor University
Dr. Jon Botsford-Vice President for Technology-Pueblo Community College
Mr. Robert Swanson-Administrator of Human Resources-Bell Helicopter, TEXTRON
Mr. Jack Peck-Vice President of Manufacturing-Mercury Tool & Die
Mr. Don Hancock-Superintendent-Connally ISD

SPECIAL RECOGNITION

Dr. Hugh Rogers recognized the need for this project, developed the baseline concepts and methodology, and pulled together industrial and academic partners from across the nation into a solid consortium. Special thanks and singular congratulations go to Dr. Rogers for his extraordinary efforts in this endeavor.

Dr. Don Pierson served as the Principal Investigator for the first two years of MASTER. His input and guidance of the project during the formative years was of tremendous value to the project team. Special thanks and best wishes go to Dr. Pierson during his retirement and all his worldly travels.

All findings and deliverables resulting from MASTER are primarily based upon information provided by the above companies, schools and labs. We sincerely thank key personnel within these organizations for their commitment and dedication to this project. Including the national survey, more than 2,800 other companies and organizations participated in this project. We commend their efforts in our combined attempt to reach some common ground in precision manufacturing skills standards and curriculum development.

MASTER DEVELOPMENT CENTER
Texas State Technical College

Texas State Technical College System
Dr. Fred Williams, President
Texas State Technical College, Waco
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Manufacturing in Texas

Economic trends have led Texas officials to recognize the need to better prepare workers for a changing labor market. The downturn in the oil, natural gas, ranching and farming industries during the last decade diminished the supply of high-paying, low-skill jobs. Growth in Texas is occurring in the low paying, low skills service industry and in the high skills, high paying precision manufacturing industry. In Texas, projected increases by the year 2000 include 4,050 jobs for machine mechanics (24% growth rate); 4,700 jobs for machinists (18% growth rate); 3,850 numeric control operators (20% growth rate); and 107,150 general maintenance repair technicians (23% growth rate). The National Center for Manufacturing Sciences (NCMS) identified that of the top twenty manufacturing states, Texas experienced the largest increase in manufacturing employment. Manufacturing will add over 70,000 additional jobs in Texas by the year 2000 with increases in both durable and non-durable goods.

Texas State Technical College (TSTC)

Texas State Technical College System (TSTC) is authorized to serve the State of Texas through excellence in instruction, public service, research, and economic development. The system's efforts to improve the competitiveness of Texas business and industry include centers of excellence in technical program clusters on the system's campuses and support of educational research commercialization initiatives. Through close collaboration with business, industry, governmental agencies, and communities, including public and private secondary and postsecondary educational institutions, the system provides an articulated and responsive technical education system.

In developing and offering highly specialized technical programs and related courses, the TSTC system emphasizes the industrial and technological manpower needs of the state. Texas State Technical College is known for its advanced or emerging technical programs not commonly offered by community colleges.

New, high performance manufacturing firms in areas such as plastics, semiconductors and aerospace have driven dynamic change in TSTC's curriculum. Conventional metal fabrication to support oil and heavy manufacturing remains a cornerstone of the Waco campus and is a primary reason TSTC took the lead in developing new curricula for machining and manufacturing engineering technology in the MAST program.

Development Team

- **Principal Investigator**: Wallace Pelton served as the primary administrator and academic coordinator for the MASTER project.
- **Subject Matter/Curriculum Expert**: Steven Betros, Site Coordinator, was responsible for developing skill standards and course/program materials for the conventional machining, mold making and manufacturing engineering technology components of the MASTER project.

Introduction:
STUDENT LABORATORY MANUAL

Prior to the development of this Student Laboratory Manual, MASTER project staff visited over 150 companies, conducted interviews with over 500 expert workers, and analyzed data from a national survey involving over 2800 participating companies. These investigations led to the development of a series of Instructor Handbooks, with each being fully industry-driven and specific to one of the technologies shown below:

Advanced CNC and CAM
Automated Equipment Repair
Computer Aided Design & Drafting
Conventional Machining
Industrial Maintenance
Instrumentation
LASER Machining
Manufacturing Technology
Mold Making
Tool And Die
Welding

Each Instructor's Handbook contains a collection of Technical Training Modules which are built around a Competency Profile for the specific occupation. **The Competency Profile which is the basis for this Student Laboratory Manual may be found on the following page (and on each of the tab pages in this book).**

This Student Laboratory Manual has been developed as an learning aid for both the instructor and for the student, and is intended to be used in conjunction with the Instructor's Handbook.

This Student Laboratory Manual is arranged by Duty groupings (Duty A, Duty B, etc.) with learning modules available for each Task Box on the Competency Profile.

This Student Laboratory Manual is supplied with an accompanying Instructor's Handbook for use by the instructor.

Each module in the Instructor's Handbook has a corresponding learning module in the Student Laboratory Manual.

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

Duties	Tasks												
A Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
	B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D Recognize Different Manufacturing, Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
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H Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MFG-A1-HO
Follow Safety Manuals and All Safety Regulations/Requirements
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Assume responsibility for the personal safety of oneself and others;
- b. Develop a personal attitude towards safety;
- c. Interpret safety manual directives;
- d. Identify and control common machine shop hazards; and,
- e. Comply with established company safety practices.

Module Outline:

- I. Assume Responsibility for the Personal Safety of Oneself and Others
  - A. Safety is a way of life not an option
  - B. Always operate with alertness and safety foremost in mind
- II. Develop a Personal Attitude Towards Safety
  - A. The key to safety is individual safety
  - B. Everyone must develop a safe attitude
  - C. Each step of the operation must be carefully planned
- III. Interpret Safety Manual Directives
  - A. Read and understand safety manual
  - B. Read machine operation instructions
- IV. Comply with Established Safety Practices
  - A. Personal safety
    - 1. Body: keep body out of line of tool edge
    - 2. Proper lifting technique
      - a. Personal lifting
        - 1) Lift with the legs, not the back
        - 2) Proper physical position while lifting
        - 3) Proper clearance for carrying
        - 4) "Buddy system" for heavy lifting
      - b. Equipment lifting
        - 1) Checking ratings for lifting devices
        - 2) Checking lifting points on lifted item
        - 3) Overhead clearance requirements
        - 4) Static lifting devices (slings, jack stands) should be used instead of moving lifting devices (jacks or forklifts) for actually holding heavy items up while working on them
  - B. Eyes: always wear safety glasses
  - C. Head: keep long hair up; wear hard hat whenever required

    - D. Ears: wear protection to prevent damage from noise
    - E. Jewelry: no rings, watches, bracelets, necklaces (they can get caught in machinery and they are conductors of electricity)
    - F. Clothing: keep sleeves and pant legs rolled down; and ties, strings, and belts away from moving parts
    - G. No horse-play
    - H. Do not talk to someone while that person is operating a machine
    - I. Do not talk to someone while you are operating a machine
- V. Identify and Control Common Machine Shop Hazards
    - A. Chip formation
    - B. Moving machine parts
    - C. Spills and other debris
    - D. Electrical lines
    - E. Hydraulic and pneumatic lines
- VI. Cover specific safety policies of the company

MFG-A1-LE
Follow Safety Manuals and All Safety Regulations/Requirements
Attachment 2: MASTER Laboratory Exercise

The purpose of this exercise is to learn to recognize hazards in the workplace. Many of the hazards which you will find there are common practices by people who simply no longer see the danger.

The instructor will guide all students through part of the facility. Each student should write down, in the space provided below, as many safety hazards as are found.

Remember, anyone can cause a hazard merely by failing to see the mop bucket that sits in front of the fire exit every day. Such tunnel vision is the result of familiarity and demonstrates the importance of keeping a fresh perspective *everyday*.

Due to the nature of this laboratory exercise, no answer key is possible.

Safety Hazards

Type	Location	Description

MFG-A1-LA
Follow Safety Manuals and All Safety Regulations/Requirements
Attachment 3: MASTER Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-A2-HO
Use Protective Equipment
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Wear protective safety clothing as required;
- b. Maintain and use protective guards and equipment on machinery;
- c. Locate and properly use protective equipment; and,
- d. Use lifting aids when necessary.

Module Outline:

- I. Wear Protective Safety Clothing as Required
  - A. Different types of safety clothing
    - 1. Protective from debris, cuts, and blows
      - a. Hard hat, safety glasses or goggles, work gloves when necessary
      - b. Sturdy footwear
      - c. Long sleeved shirt (sleeves rolled down and buttoned)
    - 2. Fire-retardant and fire-resistant clothing
      - a. Long sleeved, 100% cotton shirt
      - b. Long pants, 100% cotton
      - c. Leather chest protector, sleeves
    - 3. Optical filters to protect vision from intense light
      - a. Welding hood or goggles
      - b. Safety glasses or goggles for grinding
      - c. Tinted goggles for cutting torch work
    - 4. Breathing protection
      - a. Mask for dust, lint, smoke
  - B. Function and use of safety clothing
    - 1. Man made fiber clothing melts to worker's skin when ignited
    - 2. Prevents cuts and abrasions
    - 3. Keep shirt sleeves rolled down (hangs on equipment)
    - 4. Do not cuff pant legs (causes tripping)
    - 5. Do not wear jewelry
      - a. Catches in moving parts
      - b. Conducts electricity
    - 6. Do not wear neckties around moving parts of machinery
    - 7. Keep belts and apron strings tied and away from moving equipment
- II. Maintain and Use Protective Guards and Equipment on Machinery
  - A. Purposes of various guards

        1. Do not operate a machine until guards are in place
        2. Stop the machine to make adjustments or repairs
        3. Disconnect power before removing guards or panels
    B. Evaluation and maintenance of protective equipment
        1. Use only those electrical devices which have been approved by UL (Underwriters' Laboratories)
        2. Do not use defective equipment
        3. Report defective or unsafe equipment immediately
        4. Make sure equipment is properly grounded

III. Locate and Properly Use Protective Equipment
    A. Install safety barriers
    B. Use caution signs
    C. Install lock and tag devices
    D. Know where fire extinguishers are and how to use them

IV. Use Lifting Aids When Necessary
    A. Discuss recommended limits on single-person lifting
    B. Discuss proper lifting methods (use of the legs)
        1. Use your legs (bend your knees)
        2. Keep the load close to your body
        3. Don't twist your body while lifting
        4. Make sure you can see where you are going
        5. Wear support belts
    C. Discuss team-lifting
        1. Keep load the same height while lifting
        2. Move and lift on command
        3. Use dolly, wheelbarrow, or forklift
    D. Determine lifting ratings of lifting equipment
        1. Know how your forklift operates
        2. Understand load characteristics (weight, size, shape)
    E. Determine holding ratings of static lifting devices
    F. Evaluate positions on the workpiece for placement of lifting and holding devices

MFG-A2-LE
Use Protective Equipment
Attachment 2: MASTER Laboratory Exercise

The instructor will display as much protective equipment, such as welding masks, breathers, and hard hats as is practical and desirable. The instructor should demonstrate the proper use of this equipment.

Due to the nature of this exercise, no answer key is possible.

MFG-A2-LA
Use Protective Equipment
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-A3-HO
Follow Safe Operating Procedures for Hand and Machine Tools
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:
a. Identify and understand safe machine operating procedures; and,
b. Demonstrate safe machine operation.

Module Outline:

I. Identify and Understand Safe Machine Operating Procedures
  A. Never make adjustments on a machine while it is running
    1. Keep guards in place at all times
    2. Discontinue power before servicing
    3. Keep body parts clear of moving machinery
    4. Beware of sharp edges and flying debris
    5. Secure work pieces to prevent slipping
    6. Never stand directly in line with blades or knives
    7. Avoid kickback
    8. Feed stack into machine correctly
  B. Electrical safety
    1. Use only those electrical devices which have been approved by UL (Underwriters' Laboratories)
    2. Stand on dry surface when working on electrical equipment
    3. Replace defective cords or plugs on equipment
    4. Use only those tools that are in good condition
    5. Use only carbon dioxide or dry chemical fire extinguishers for control of electrical fires
    6. Obtain help when working on equipment that may become energized
  C. Avoid horseplay and practical jokes
  D. Keep work area clean.

II. Demonstrate Safe Machine Operation
  A. Good housekeeping
    1. Materials and equipment should be stacked straight and neat
    2. Keep aisles and walkways clear of tools, materials, and debris
    3. Dispose of scraps and rubbish daily
    4. Clean up spills
    5. Clean and store hand tools
  B. Good techniques
    1. Always walk - do not run
    2. Never talk to or interrupt anyone who is operating a machine

3. Never leave tools or pieces of stock lying on table surface of a machine being used
4. When finished with a machine, turn power OFF and wait until blades or cutters have come to a complete stop before leaving
5. Check stock for defects before machining
    a. Do not use a machine until you understand it thoroughly
    b. Do not jam or rush stock into machinery
    c. Keep guards in place
    d. Make sure power is OFF before working on or servicing
6. Keep hands and fingers away from moving parts
7. Don't try to run too small a piece through the machine
8. Use a brush to clean the surface table
9. Keep your eyes focused on what you are working on
10. Never use an air hose to blow debris off yourself or other workers
11. Report faulty machinery to your supervisor
12. Make sure machinery is properly grounded
13. Never leave a piece of machinery that is running unattended
14. Make sure stack is solidly supported

C. Miscellaneous materials
1. Molten metal - can splash and cause serious burns
2. Chemicals - burn or irritate the skin or cause eye damage
3. Broken glass - causes cuts, can get in the eyes
4. Pointed objects - knives, screwdrivers, punches, staples can puncture the skin
5. Rough material - can scrape your skin and cause infections

D. Machinery
1. Understand the safety regulations that involve the guarding of moving parts
2. Know what parts of the equipment are energized
3. Use all safeguards that have been provided to protect people from machinery
4. See that all guards and protectors are in place before you start to work
5. If you must work nearer, turn the machine off and lock out the power
6. Never work in, around, or near dangerous, unguarded openings without wearing a safety belt and a lifeline that is properly seamed

E. One-fifth of all injuries on the job involve moving parts, machinery, or tools

Follow Safe Operating Procedures for Hand and Machine Tools

Attachment 2: MASTER Laboratory Exercise

For this exercise, the instructor should allow the students to observe other workers at their stations. The students should look for only practices related to safety. Upon returning to class, the students and instructor should discuss what they saw.

NOTE TO ALL STUDENTS: Unless your instructor tells you otherwise, all questions are to be directed to the instructor only. Do **not** disturb you fellow workers at their stations. Such distractions, in and of themselves, pose risks!

Due to the nature of this exercise, no answer key is possible.

MFG-A3-LA
Follow Safe Operating Procedures for Hand and Machine Tools
Attachment 3: MASTER Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-A4-HO
Maintain a Clean and Safe Work Environment
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Keep work areas clean;
b. Clean machine/hand tools when work is completed;
c. Put tools away when work is finished;
d. Keep isles clear of equipment and materials;
e. Perform preventive maintenance as required; and,
f. Understand chemical hazards and the use of Material Safety Data Sheets (MSDS).

Module Outline:

I. Keep Work Areas Clean
  A. Discuss the associated dangers of the most common hazards of the work place
    1. Tripping/falling hazards caused by spills, loose objects, etc.
      a. Wipe up spills immediately
      b. Dispose of scrap material
      c. Do not wear loose clothing
      d. Never roll sleeves or pants
      e. keep shoe strings tied
      f. Position electrical cords and air hoses in safe areas
    2. Chemical hazards
      a. Inhalants
      b. Chemical burns
      c. Flammable liquids
      d. Explosives and explosive combinations
      e. Toxins
    3. Electrical hazards
    4. High-pressure hazards
  B. Discuss methods of avoiding and correcting common hazards
II. Clean Machine/Hand Tools When Work Is Completed
III. Put Tools Away When Work Is Finished
IV. Keep Isles Clear of Equipment and Materials
V. Perform Preventive Maintenance as Required
  A. Discuss that certain machines require extra precautions
  B. Discuss how general maintenance enhances general safety
VI. Understand the Use of Material Safety Data Sheets (MSDS)
  A. What chemicals have MSDS?

B. Where are the MSDS kept?
C. What information is on the MSDS?
  1. Product identification
    a. Specific product name and common name
    b. Precautionary labeling
    c. Safety equipment
    d. Precautionary label statements
    e. Storage color code
  2. Hazardous components
  3. Physical data
    a. Boiling point
    b. Vapor pressure
    c. Melting point
    d. Vapor density
    e. Specific gravity
    f. Evaporation rate
    g. Solubility in water
    h. Percentage of volatile components by volume
    I. Appearance & odor
  4. Fire and explosion hazard data
    a. Flash point
    b. NFPA 704M rating
    c. Flammable limits (upper and lower)
    d. Fire extinguishing media
    e. Special fire-fighting procedures
    f. Toxic gases produced
  5. Health hazard data
    a. Threshold limit value
    b. Permissible exposure limit
    c. Toxicity
    d. Carcinogenicity
    e. Effects of over-exposure
    f. Target organs (those most affected by exposure)
    g. Medical conditions aggravated by exposure
    h. Routes of entry
    I. Emergency and first-aid procedures
  6. Reactivity data
    a. Stability
    b. Hazardous polymerization
    c. Conditions to avoid
    d. Incompatible materials
    e. Decomposition products
  7. Spill and disposal procedures
    a. Procedures: spill or discharge
    b. Procedures: disposal

    - c. EPA hazardous waste number
- 8. Protective equipment
    - a. Ventilation
    - b. Respiratory protection
    - c. Eye/skin protection
- 9. Storage and handling precautions
    - a. Storage color code
    - b. Special precautions
- 10. Transportation data and additional information
    - a. Domestic transport
        - 1) DOT shipping name
        - 2) Hazard class
        - 3) UN/NA
        - 4) Labels
        - 5) Reportable quantity
    - b. International
        - 1) IMO shipping name
        - 2) Hazard class
        - 3) UN/NA
        - 4) Labels

MFG-A4-LE
Maintain a Clean and Safe Work Environment
Attachment 2: MASTER Laboratory Exercise

The instructor will guide all students through part of the facility. Each student should write down as many safety hazards as are found. While this may appear to be an exact duplicate of MFG-A1, the purpose of this exercise is to determine how much more aware of safety and hazards the students have become.

Upon returning to class, the students and the instructor should discuss what the students observed on this tour. Each student should compare his answers to those from MFG-A1, noting any differences and the reasons for those differences.

Due to the nature of this laboratory exercise, no answer key is possible.

Safety Hazards

Type	Location	Description	Recommendations

MFG-A4-LA
Maintain a Clean and Safe Work Environment
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-A5-HO
Lift Safely
Attachment 1: MASTER Handout

Standards of Performance:

Student shall demonstrate safety work habits in the work shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

Objective(s):

Upon completion of this module the student will be able to:

a. Identify the consequences of improper lifting techniques;
b. Recognize when it is unsafe to lift an object alone;
c. Demonstrate proper lifting techniques; and,
d. Identify safety concerns to be addressed when lifting rough, sharp or fragile items.

Module Outline:

I. Discuss the Importance of Lifting Safely
  A. Give each student a copy of the following attachments:
    1. Laboratory aid
    2. Objectives, reading assignments, and module outline
    3. Laboratory worksheet
II. Identify the Steps to Manually Lift Safely
  A. Estimate the load to be lifted. If it is heavier than one person should attempt, get help.
  B. Place feet properly. Spread your feet slightly (comfortably), with one foot slightly ahead of the other and alongside the object.
  C. Bend knees, kneel, or squat. Get close enough to the load to reach under it without bending the back.
  D. Use blocking under objects to get a handhold and to prevent crushed fingers.
  E. Get a good grip. Be sure you can maintain your grip on the object. Use gloves when handling sharp or rough objects.

        F. Let the legs do the lifting. To rise, straighten your legs, letting the powerful leg, arm, and shoulder muscles do the lifting.
        G. Do not turn the body at the waist while carrying a load.
        H. Lower the load to the floor from the carrying position by bending the knees while keeping the back straight. This keeps the load on the leg and arm muscles. Keep fingers and toes clear as the load is set.

III. Discuss Handling Specific Shapes
    A. Locate center of gravity and use this area to lift
    B. Place as much weight as possible as close to lifting mechanism
    C. Place flat weight on button

IV. Discuss Equipment for Material Handling
    A. Hand Trucks
    B. Powered Trucks
    C. Conveyers

V. Discuss and Demonstrate Safe Use of Hand Trucks
    A. Place most of the weight on bed of hand truck
    B. May require two people if one object is difficult to lift on side
    C. Hold object tightly as handle is pulled back
    D. Adjust handle position so more weight is on hand end
    E. After movement, hold object tightly as handle is moved upward
    F. Lift object on one side so bed of truck can be moved away from object

VI. Discuss and Demonstrate Use of Powered Hand Trucks
    A. Watch out for people
    B. Drive unit slowly
    C. Use manual lifting rules

VII. Discuss and Demonstrate Safe Use of Conveyers
    A. Watch for pinch points
    B. Exercise caution when loading and unloading objects
    C. Do not overload conveyers. Rollers may not move freely

VIII. Discuss and Demonstrate Safe Use of Chains and Slings
    A. Storage area should be clean and dry
    B. Watch for pinch points
    C. Inspect for defects before using:
        1. Chains
            a. Wear
            b. Stretch
            c. Distortion
            d. Nicks
            e. Cracks
            f. Gauges
        2. Slings
            a. Wear
            b. Stretch
            c. Distortion
            d. Flat, Sling Spots

- D. Types
    - 1. Slings
        - a. Choker
        - b. Double Choker
        - c. Bridle
        - d. Basket
        - e. Double Basket

IX. Discuss and Demonstrate Safe Use of Chains and Slings

MFG-A5-LE
Lift Safely
Attachment 2: MASTER Laboratory Exercise

EXERCISE

1. Established standards for safety and conduct shall be followed.
2. Equipment required:
   Hand truck
   Conveyor
   Chains
   Sling
   Face shield
   Side shields
3. Exercises below must be taken in sequence. Instructor must confirm proficiency prior to student's progressing to next exercise.
   a. Practice manual lifting.
   b. Practice using hand truck to carry objects.
   c. Practice using powered truck to carry objects.
   d. Practice handling specific shapes.
   e. Practice lifting with slings.
   f. Practice lifting with chains.
4. Instructor will guide each exercise.
5. Instructor will grade each exercise.

MFG-A5-LA
Lift Safely
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-A6-HO
Control Fire Hazards
Attachment 1: MASTER Handout

Standards of performance:

Student shall demonstrate safe work habits in the work shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify what causes fires;
b. Explain how electrical equipment cause fire;
c. List good housekeeping rules that help prevent fires;
d. Know what to do in case of fire;
e. Identify the technician's responsibilities relative to fire safety;
f. List conditions required for fire to exist;
g. Name four classes of fires;
h List four typical causes of industrial fires described in the lesson;
i. Match the correct class extinguishers to a given fuel source; and,
j. Demonstrate proper use of a fire extinguisher.

Module Outline:

I. Identify Conditions Required for a Fire to Exist
    A. Fuel
    B. Oxygen
    C. Heat
II. Four Classes of Fire
    A. Ordinary combustibles
    B. Flammable liquids
    C. Electrical
    D. Combustible metals
III. List Four Typical Causes of Workplace Fires
    A. Careless smokers
    B. Electrical overloads

  - C. Inadequate fire watch for welding and cutting operations
  - D. Combustible dust in the atmosphere
- IV. Improperly Maintained Electrical Equipment
  - A. Worn or frayed insulation on wiring
  - B. Incorrect fuse size
  - C. Improper use of extension cords
  - D. Improper grounding
  - E. Overloaded conductors, motors, outlets of unattended heating equipment
- V. Obey Smoking Rules
  - A. Don't smoke near anything that can burn (paper, wood, flammables)
  - B. Put cigarettes and matches out before throwing away
- VI. Good Housekeeping Prevents Fires
  - A. Keep motors and machine tools free of dust and grease
  - B. Don't let belts and transmission shafts overheat
  - C. Dispose of combustible scraps daily
  - D. Restrict welding and cutting operations to separate fire proof rooms
  - E. Check chemical labels
  - F. Install smoke detectors
  - G. Keep aisles, passages and fire doors clear
  - H. Don't store oxygen cylinders near combustible materials
- VII. Plan For an Emergency
  - A. Know how to get out in case of fire
    - 1. Know escape route
    - 2. Practice evacuations
  - B. Turn in the alarm
    - 1. Turn off equipment
    - 2. Close non-escape windows
    - 3. Evacuate by assigned routes if possible
  - C. Know the location of fire extinguishers
    - 1. Know the classification of fire extinguisher
    - 2. Learn how to use fire extinguishers
- VIII. Technician's Responsibility
  - A. Each employer will have company specific rules
  - B. Unless the technician is part of the company fire fighting crew or fire brigade
    - 1. Notify every one in the area to evacuate
    - 2. Get to a phone and notify appropriate department
    - 3. Something as simple as an ash tray or trash can can start fire that may be easily and safely extinguished. Appropriate department must be notified of the event
    - 4. Employees are responsible for keeping the workplace safe and for reporting unsafe conditions
- IX. Demonstrate to Class How to Match the Correct Extinguishers for the Class of Fire

X. Demonstrate Proper Use of a Fire Extinguisher

Fire Extinguisher
Agent Characteristics

Suitable for use on what type of fire: B C

Agent Characteristics:
- Regular or Ordinary Dry Chemical
- Basically Sodium Bicarbonate
- Discharges a white cloud
- Leaves residue
- Non-freezing

Average Size - 1 to 30 lbs.
Horizontal Range - 5 to 20 ft.
Discharge Time - 8 to 25 sec.

Suitable for use on what type of fire: ABC or BC

Agent Characteristics:
- Multipurpose Dry Chemical
- Basically Ammonium Phosphate
- Discharges a yellow cloud
- Leaves residue
- Non-freezing
- Some extinguishers utilizing this agent do not have an "A" rating; however, they are designated as having "A" capability.

Average Size - 2 to 30 lbs.
Horizontal Range - 5 to 20 ft.
Discharge Time - 8 to 25 sec.

Suitable for use on what type of fire: B C

Agent Characteristics:
- Purple-K Dry Chemical
- Basically Potassium Bicarbonate
- Discharges a bluish cloud
- Leaves residue
- Non-freezing

Average Size - 2 to 30 lbs.
Horizontal Range - 5 to 20 ft.
Discharge Time - 8 to 25 sec.

Suitable for use on what type of fire: B C

Agent Characteristics:
- KCL Dry Chemical
- Basically Potassium Chloride
- Discharges a white cloud
- Leaves residue
- Non-freezing
- Potassium Chloride/Urea

Average Size - 2 to 30 lbs. (11 to 23)
Horizontal Range - 5 to 20 ft. (15 to 30)
Discharge Time - 8 to 25 sec. (20 to 31)

Suitable for use on what type of fire: B C

Agent Characteristics:
- Carbon Dioxide
- Basically an inert gas that discharges a cold white cloud
- Leaves no residue
- Non-freezing

Average Size - 2 ½ to 20 lbs.
Horizontal Range - 3 to 8 ft.
Discharge Time - 8 to 30 sec.

Suitable for use on what type of fire: B C

Agent Characteristics:
- Halogenated Agent
- Basically halogenated hydrocarbons
- Discharges a white vapor
- Leaves no residue
- Non-freezing

Average Size - 2 ½ lbs.
Horizontal Range - 4 to 8 ft.
Discharge Time - 8 to 10 sec.

Suitable for use on what type of fire: A

Agent Characteristics:
- Water
- Basically tap water
- Discharges in a solid or spray stream
- May contain corrosion inhibitor which leaves a yellow residue
- Protect from freezing

Average Size - 2 ½ gal.
Horizontal Range - 30 to 40 ft.
Discharge Time - 1 minute

Suitable for use on what type of fire: A

Agent Characteristics:
- Anti-Freeze Solution
- Basically a Calcium Chloride solution to prevent freezing
- Discharges a solid or spray stream
- Leaves residue
- Non freezing

Average Size - 2 ½ gal.
Horizontal Range - 30 to 40 ft.
Discharge Time - 1 minute

Suitable for use on what type of fire: A B

Agent Characteristics:
- Loaded Stream
- Basically an alkali-metal-salt solution to prevent freezing
- Discharges a solid or spray stream
- Leaves residue
- Non freezing

Average Size - 2 ½ gal.
Horizontal Range - 30 to 40 ft.
Discharge Time - 1 minute

Suitable for use on what type of fire: B

Agent Characteristics:

- Foam
- Basically a water and detergent
- Discharges a foamy solution
- After evaporation, leaves a powder residue
- Protect from freezing

Average Size - 18 oz.
Horizontal Range - 10 to 15 ft.
Discharge Time - 24 sec.

Suitable for use on what type of fire: D

Agent Characteristics:

- Dry Powder Special Compound
- Basically Sodium Chloride or Graphite materials
- Agent is discharged from an extinguisher in a solid stream or is applied with a scoop or shovel to smother combustible metal
- Leaves residue
- Non-freezing

Average Size - 30 lbs.
Horizontal Range - 5 to 20 ft.
Discharge Time - 25 to 30 sec.

MFG-A6-LE
Control Fire Hazards
Attachment 2: **MASTER** Laboratory Exercise

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1. Established standards for safety and conduct shall be followed.

2. Equipment required:
   Dust Mask;
   Gloves;
   Fire extinguishers;
   Face shield; and,
   Side shields.

3. Instructor must confirm proficiency prior to student progressing

4. Practice exercises
   A. Instructor will demonstrate proper usage of fire extinguishers
   B. Student shall practice using fire extinguishers

MFG-A6-LA
Control Fire Hazards
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-A7-HO
MSDS/Control Chemical Hazards
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Define hazardous material;
- b. Identify hazardous material;
- c. Know the physical and chemical characteristics;
- d. Describe storage, transportation, disposal of hazardous waste; and,
- e. Explain material safety data sheets.

Module Outline:

- I. Define Hazardous Materials According to the EPA
    - A. What makes a material hazardous?
        - 1. It is hazardous if it causes harm to people or environment
- II. Identify Hazardous Materials
    - A. Material Safety Data Sheets (MSDS)
        - 1. Companies that make and distribute hazardous substances must provide your company with a MSDS on hazardous material
        - 2. MSDS developed by OSHA
        - 3. MSDS is part of the Hazard Communication Standard or Right to Know regulation
        - 4. MSDS is an easy reference for information on hazardous substances
    - B. Information in MSDS
        - 1. What it is
        - 2. Who makes or sells it
        - 3. Where they are located
        - 4. Why it is hazardous
        - 5. How you can be exposed to the hazard
        - 6. Conditions that could increase the hazard
        - 7. How to handle the substance safely
        - 8. Protection to use while working with it
        - 9. What to do if exposed
        - 10. What to do if there is a spill or emergency
- III. Know the Chemical and Physical Characteristics
    - A. Corrosive
        - 1. Burns skin or eyes on contact
    - B. Explosive
    - C. Flammable

        1. Catches fire easily
    - D. Radioactive
    - E. Reactive
        1. Burns, explodes
        2. Releases toxic vapors
    - F. Toxic
        1. Causes illness or possibly death

IV. Describe Storage, Transportation, Disposal
    - A. Resource Conservation and Recovery Act (RCRA)
        1. Designed to reduce hazards of waste by tracking and regulating the substance
        2. Method used is called from cradle (creation) to grave (disposal)
        3. Tells what hazards are and how to keep track of them
        4. Sets up rules for handling wastes
        5. Provides strict documentation system to track them
    - B. Your employer may have to report to the Environmental Protection Agency (EPA) on how the company is meeting the RCRA responsibilities
    - C. The law requires companies that treat, store, or dispose of hazardous wastes to:
        1. Must have a permit
        2. Identify and analyze new hazardous waste
        3. Provide a secure facility that keeps unauthorized people out
        4. Inspect the facility regularly
        5. Have a contingency plan for fire, explosion, and spills
        6. Practice emergency response for fire, explosion, spills
        7. Provide proper protective clothing and equipment
        8. Maintain EPA-required records

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	Tasks												
A	**Practice Safety**	A-1 Follow safety manuals and all safety regulations/requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/Control chemical hazards						
B	**Apply Mathematical Concepts**	B-1 Perform basic arithmetic functions	B-2 Convert fractions/decimals	B-3 Convert Metric/English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	**Interpret Engineering Drawings and Control Documents**	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	**Recognize Different Manufacturing Materials and Processes**	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	**Measure/Inspect**	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	**Perform Conventional Machining**	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/abrasive machines					
G	**Perform Advanced Machining**	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	**Program Using CAM System**	H-1 Understand CAD/CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	**Use Computers**	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	**Participate in Total Quality and SPC Activities**	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	**Maintain Electrical Devices**	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	**Maintain Hydraulic/Pneumatic Devices**	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MFG-B1-HO
Perform Basic Arithmetic Functions
Attachment 1: MASTER Handout

Objective(s):

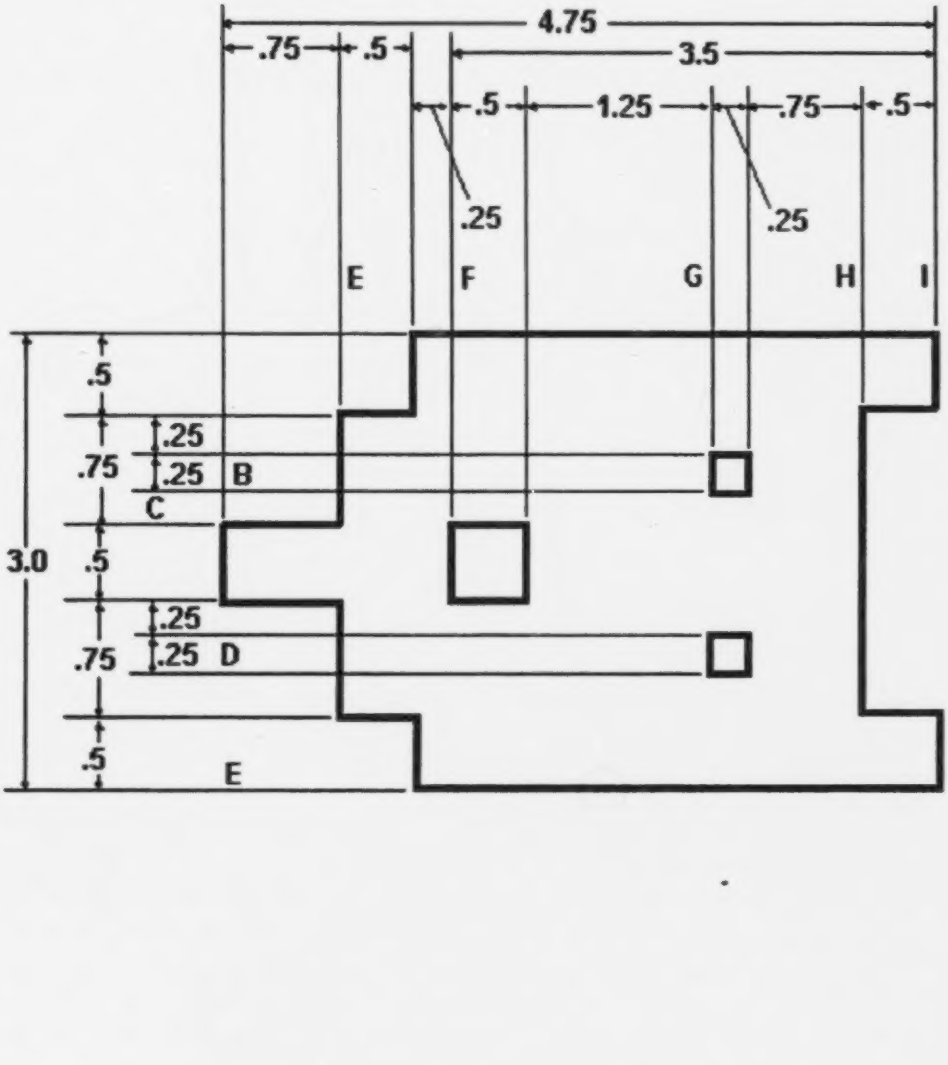
Upon completion of this unit the student will be able to:

- a. Add, subtract, multiply, and divide whole numbers;
- b. Add, subtract, multiply, and divide fractions; and,
- c. Add, subtract, multiply, and divide decimals.

Module Outline:

- I. Add, Subtract, Multiply, and Divide Whole Numbers
  - A. Addition of whole numbers
  - B. Subtraction of whole numbers
  - C. Multiplication of whole numbers
  - D. Division of whole numbers
  - E. Hierarchy of operations
- II. Add, Subtract, Multiply, and Divide Fractions
  - A. Common operations
    - 1. Least common denominator
    - 2. Factoring for reduction
    - 3. Improper fractions
    - 4. Mixed numbers
  - B. Addition
  - C. Subtraction
  - D. Multiplication
  - E. Division
- III. Add, Subtract, Multiply, and Divide Decimals
  - A. Aligning the decimal (addition and subtraction)
  - B. Moving the decimal
    - 1. In division, move the decimal to the right until it is eliminated in the divisor. Move the decimal the same number of places to the right in the dividend.
    - 2. In multiplication, count the total number of decimals places in the two numbers being multiplied. Beginning in the product at the *right-most digit,* count off the same number of places and place the decimal.

MFG-B1-LA
Perform Basic Arithmetic Functions
Attachment 2: MASTER Laboratory Aid



4.75
.75
.5
3.5
.5
1.25
.75
.5
.25
.25
E
F
G
H
I
.5
.25
.75
.25
B
C
3.0
.5
.25
.75
.25
D
.5
E

MFG-B2-HO
Convert Fractions/Decimals
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Write fractions as decimals;
b. Write decimals as fractions; and,
c. Use fractions and decimals interchangeably.

Module Outline:

I. Write Fractions as Decimals
  A. Understand and be able to use equivalent fractions
  B. Write fractions in lowest terms
  C. Understand improper fractions and mixed numbers
  D. Be able to write fractions as decimals by performing the indicated division
II. Write Decimals as Fractions
  A. Understand the place value in decimals
  B. Understand how to find the fraction or mixed number equivalent of decimals by writing the digits over the place value and reducing this to the lowest terms
III. Use Fractions and Decimals Interchangeably
  A. Understand how fractions and decimals can be used interchangeably to represent the same value
  B. Be able to determine the best representation, fraction or decimal, for a given industrial problem
IV. Common Technical Conversions
  A. These are the six most important conversions from denominative fractions to decimal fractions
    1. 1/64 is *about* .016 (sixteen thousandths)
    2. 1/32 is *about* .031 (thirty-one thousandths)
    3. 1/16 is *about* .062 (sixty-two thousandths)
    4. 1/8 is .125 (one hundred twenty-five thousandths)
    5. 1/4 is .250 (two hundred fifty thousandths)
    6. 1/2 is .500 (five hundred thousandths)
  B. The trick to quickly converting these fractions is to think of them just like they were building blocks. For example, how much is 11/16 inch in thousandths? 11/16 is actually 1/2 + 1/8 + 1/16, so it is also .500 + .125 + .062, or .687.
  C. If you, the technician, will learn the six basic conversions listed above, then you will have won half the battle of fractional conversions.

D. It is also helpful to think in thousandths. Don't think of .5 as one-half or five tenths, think of it as 500 thousandths. Thinking this way will automatically align the decimal places for you and allow you to quickly add and subtract measurements.

E. By the same token, it is easier to think in 64ths than it is to carry around all those fractions in your head. Converting fractions can cause errors because it is another step. Since the assumed standard of tolerance in binary fractions is 1/64 inch, *think that way*. One-half becomes 32/64; one-eighth, 8/64. The arithmetic almost does itself when all the fractions in your head have common denominators.

MFG-B3-HO
Convert Metric/English (Customary or English) Measurements
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Make inch, foot, and yard (English) measurements using rulers, calipers, and height gages;
b. Make millimeter, centimeter, meter (metric) measurements using metric rulers, calipers, and height gages; and,
c. Use English and metric measurements interchangeably.

Module Outline:

I. Make Inch, Foot, and Yard (English) Measurements Using Rulers, Calipers, and Height Gages
    A. Know the units of length, their symbols and relationships
    B. Be able to convert from one unit of length to another
    C. Be able to choose the degree of accuracy desired when making length measurements
    D. Be able to measure to the nearest 1/64 inch using rulers, and to the nearest .001" using calipers and height gages
II. Write Millimeter, Centimeter, and Meter (Metric) Measurements Using Metric Rulers, Calipers, and Height Gages
    A. Know the metric units of length, their symbols and relationships
    B. Be able to convert from one metric unit of length to another
    C. Be able to choose the degree of accuracy desired when making metric unit of length measurements
    D. Be able to measure to the nearest centimeter or millimeter using metric rulers, calipers, and height gages
III. Convert Metric/English Units of Length
    A. Know how to convert metric to English units using a conversion factors table
    B. Know how to convert English units to metric units using a conversion factors table

MFG-B4-HO
Perform Basic Algebraic Operations
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Understand basic algebraic symbols and expressions; and,

b. Use equations to solve problems.

Module Outline:

I. Understand Basic Algebraic Symbols and Expressions
  A. Symbols
    1. Addition "+"
    2. Subtraction "-"
    3. Multiplication "·"; "x", and parentheses
    4. Division "÷" and "/"
    5. Exponents are generally limited to the term "square" in linear measurements. This is the "^{2}" notation.
  B. Expressions
    1. Sum: the total amount resulting from addition
    2. Difference: the remaining amount resulting from subtraction
    3. Product: the total amount resulting from multiplication
    4. Exponent: a superscript which indicates the number of times a quantity is multiplied by itself
    5. Quotient: the amount resulting from division

II. Use a Few Easy-to-Remember Rules to Solve Equations
  A. *P*lease *E*xcuse *M*y *D*ear *A*unt *S*ue indicates the order in which equations are solved. Each letter shows one of the algebraic notations or functions: Parentheses, Exponents, Multiply, Divide, Add, Subtract.
    1. In the expression $(x - y)^2 + 2x^2 - y^2$, the *p*arentheses, which must be worked first, indicate that y must be subtracted from x. Since we don't know what x and y are, we can't do that, and must move on.
    2. The next step is to square the term $(x - y)$, as indicated by the *e*xponent. This gives us $x^2 - 2xy + y^2 + 2x^2 - y^2$.
    3. There is no operable *m*ultiplication or *d*ivision in this expression, so we move on.
    4. Grouping all the like terms to make seeing the answer easier, we have $x^2 + 2x^2 + y^2 - y^2 - 2xy$.
    5. *A*dding, we now have $3x^2 + y^2 - y^2 - 2xy$.
    6. *S*ubtracting, which is the final step, renders $3x^2 - 2xy$.

B. *FOIL* gives the order in which you multiply the terms in expressions. Let us go back to squaring (multiplying by itself) (x - y) from the expression above.

   1. *F*irst terms first, so, in (x - y)(x - y), multiply the two x's first. This give us x^2.
   2. *O*utside terms come next, so multiply the first x by the second y. This gives us $x^2 - xy$.
   3. *I*nside terms come next, so multiply the first y by the second x. This gives us $x^2 - xy - xy$.
   4. *L*ast terms are last, so multiply the two y's. This gives us a complete (if complex) $x^2 - xy - xy + y^2$.
   5. Simplifying gives us the expression $x^2 - 2xy + y^2$.

C. Thinking about algebra can be daunting to almost anybody, but once you see that algebra is just juggling done with numbers and with a lot of two-dollar words stuck all over it, algebra becomes rather simple. Remember, algebra is just taking the four basic mathematic operations (addition, subtraction, multiplication, and division) and using them to find out something that you didn't know to start with.

D. Word problems are what you will encounter every day in the shop. Someone will tell you to get so much material and make so many parts from it. As you progress in skill, they will tell you to get such-and-such material and make so many parts from it. Your mastery of basic algebra will make these problems easy to solve.

MFG-B5-HO
Use Practical Geometry
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to:

a. Calculate angles;
b. Calculate length of triangle sides;
c. Calculate radius, diameter, circumference, and area of a circle; and,
d. Understand the applications of planar geometry to solid forms.

Module Outline:

I. Some Rules of Angles
    A. Angles are usually expressed in degrees, minutes, and seconds
    B. No angle has more than 360°
    C. Angles have three points which determine them
    D. An angle having 90° is a right angle
II. Triangles
    A. Pythagorean Theorem: $a^2 + b^2 = c^2$
    B. All the angles in a triangle will add up to 180°, every day, every time, every triangle
    C. Have three corners. If one of them is 90°, then it is a right triangle.
    D. The absolute size of a triangle cannot be determined by its angles alone. At least one side must be known.
III. Circle
    A. 360°, every day, every time, every circle
    B. Pi (π) 3.1416 and its importance
    C. $2\pi r = d$, where r is the circle's radius and d, its diameter
IV. Rectangles and Parallelograms
    A. Squares and rectangles
        1. Have four 90° corners
        2. Squares are rectangles all of whose sides are equal
    B. Parallelograms
        1. Have four corners not 90°
        2. Have (at least) two parallel sides
V. Relating Planar Geometry to Solid Forms

In reality, planar geometry is an abstract way of looking at *parts* of solid things. Look at a piece of 1" CRS—at each end, it is a circle, so all the rules of circles apply to it, but only when looked at from the end. When you look at it from the sides, the rules for lines apply. So, that piece of 1" CRS, which is actually a cylinder, can be looked at as two circles joined by a line. Square workpieces have the same properties. No matter which way you look at them, each face is a rectangle or a parallelogram; and each face is subject to the rules of rectangles and parallelograms. Tapers are unequal circles joined by an incomplete triangle.

MFG-B6-HO
Understand Basic Trigonometry
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Solve for unknown angles;
- b. Solve for unknown sides; and,
- c. Calculate bolt hole patterns.

Module Outline:

- I. Solve for Unknown Angles
  - A. Right triangles
    - 1. Sine Law: sin a = side opposite divided by hypotenuse
    - 2. Cosine Law: cos a = side adjacent divided by hypotenuse
    - 3. Tangent Law: tan a = side opposite divided by side adjacent
    - 4. ***O***scar ***H***as ***A*** ***H***eap ***O***f ***A***pples is a quick device to remember the above three runes.
      - a. Sine $\angle$ = ***O***pposite/***H***ypoteneuse
      - b. Cosine $\angle$ = ***A***djacent/***H***ypoteuse
      - c. Tangent $\angle$ = ***O***pposite/***A***djacent
  - B. Oblique Triangles
    - 1. Lengths of three sides (A, B, C) all known
      - a. $\text{Cos } a = (B^2 + C^2 - A^2)/2BC$
      - b. $\text{Sin } b = (B \text{ x } \sin a)/A$
      - c. $c = 180° - (a + b)$
    - 2. Two angles (a and b) known
      $c = 180° - (a + b)$
    - 3. Two sides and interior angle (A, c, B) known
      - a. $\text{Tan } a = (A \text{ x } \sin c)/B-(A \text{ x } \cos c)$
      - b. $b = 180° - (a + c)$
      - c. $C = (A \text{ x } \sin c)/\sin a$
    - 4. Two sides and an opposite angle (a, A, B) known
      - a. $\text{Sin } b = (B \text{ x } \sin a)/A$
      - b. $c = 180° - (a + b)$
      - c. $C = (A \text{ x } \sin c)/\sin a$
- II. Solve for Unknown Sides
  - A. Right triangles, any two sides known, where C is the hypotenuse
    $A^2 + B^2 = C^2$
  - B. One side and two angles (a, b, A) known
    - 1. $c = 180° - (a + b)$
    - 2. $B = (A \text{ x } \sin b)/\sin a$

3. $C = (A \times \sin c)/\sin a$

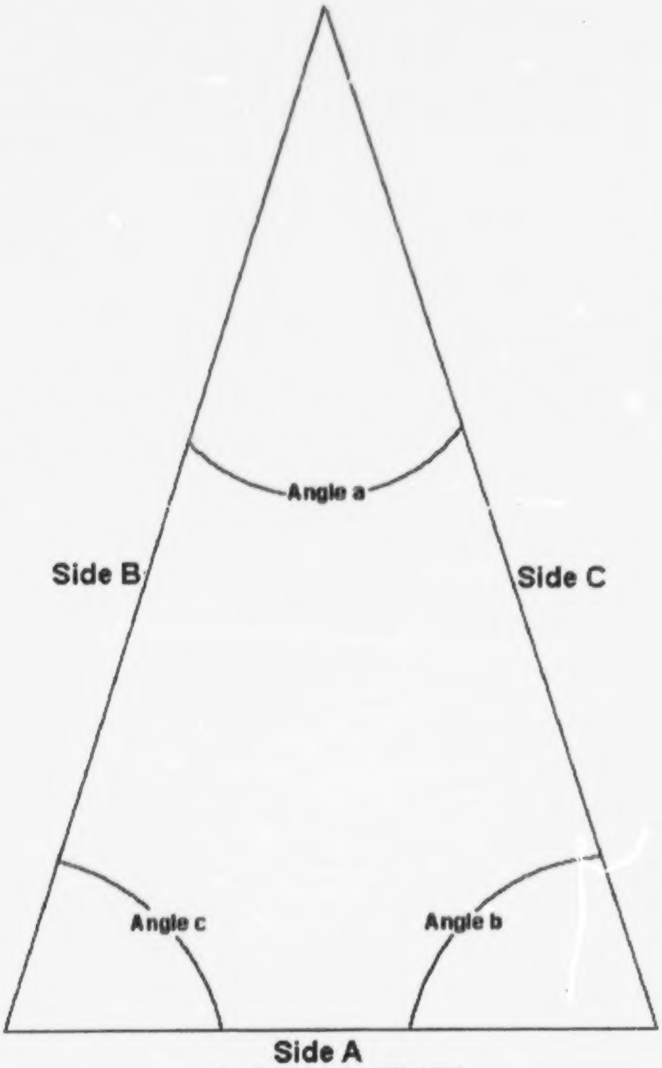
C. Two sides and the interior angle (A, B, *c*) known
$C = \sqrt{[A^2 + B^2 - (2AB \times \cos c)]}$

D. Three angles known
It is impossible to determine the actual length of any side when only the sizes of the three angles are known. The length of at least one side *must* be known in order to calculate the lengths of the other sides.

III. Calculate Bolt Hole Patterns

A. Discuss the construction of reference triangles to solve bolt-hole patterns

B. Discuss circles and their uses in figuring bolt-hole patterns.


Angle a
Side B
Side C
Angle c
Angle b
Side A

Basic Triangle - MFG-B6

MFG-B7-HO
Calculate Speeds and Feeds for Machining
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Calculate RPM for various metals and various tools; and,
b. Calculate feed for various metals, tools, and depths of cut.

Module Outline:

I. Calculate RPM for Various Metals and Various Tools
   - A. Cutting speed (CS) defined - the surface feet per minute (sf/min) or meters per minute (m/min) at which the metal may be machined efficiently. When work is machined on a lathe, it must be turned at a specific number of revolutions per minute (rpm), *depending on its diameter*, to achieve the proper cutting speed. When work is machined on a milling machine, the cutter must be revolved at a specified number of rpm's, *depending on its diameter*, to achieve the proper cutting speed.
   - B. Factors affecting proper cutting speed
     1. Type of work material (aluminum, bronze, steel, etc.)
     2. Type of cutter (high-speed, carbide etc.)
     3. Diameter of the cutter
     4. Surface finish required
     5. Depth of cut
     6. Rigidity of the machine and the work setup
   - C. Sources for determining recommended cutting speeds
     1. *Machinery's Handbook*
     2. The text
     3. Cutting tool and insert manufacturers
     4. Experience of the machinist
   - D. Determining correct RPM
     1. Inch RPM calculations ...

        $\text{RPM} = (\text{CS} \times 4) \div \text{Diam.}$
     2. Metric RPM calculations ...

        $\text{RPM} = (\text{CS (m)} \times 1000) \div (\pi \times \text{Diam. (mm)})$
     3. See charts 7.1 and 7.2 in this module
   - E. Problems related to using the wrong cutting speed
     1. Cutting speed too slow
        - a. Time will be lost for machining (low production rates)
        - b. Broken tool bits
     2. Cutting speed too fast

        a. Cutting tool edge breaks down
        b. Loss in production time due to reconditioning/replacing the tool
    F. Student practice using the "Determining Correct RPM" exercise and recommended speed charts found in this module

II. Calculate Feed for Various Metals, Tools, and Depths of Cut
    A. Feed defined - feed may be defined as the distance the tool advances into the work for every revolution.
        1. When work is machined on a lathe, feed is the distance, in inches (or millimeters), the cutting tool advances along the length of the work for every revolution of the spindle. Lathe feeds are generally expressed as inches (or millimeters) per revolution (ipr).
        2. When work is machined on a milling machine, feed is the distance, in inches (or millimeters) per minute, that the work moves into the cutter. Milling feeds are generally expressed as inches (or millimeters) per minute (ipm).
    B. Factors affecting proper feed
        1. Depth and width of cut
        2. Design or type of cutter
        3. Sharpness of the cutter
        4. Workpiece material
        5. Strength and uniformity of the workpiece
        6. The of finish and accuracy required
        7. Power and rigidity of the machine
    C. Sources for determining cutting optimal cutting speeds
        1. *Machinery's Handbook*
        2. The text
        3. Cutting tool and insert manufacturers
        4. Experience of the machinist
    D. Methods for determining correct feed
        1. Depth of cut - rule of thumb
            a. When possible, only two cuts should be used to bring a part to size: a roughing cut and a finishing cut.
            b. Since the purpose of a roughing cut is to remove excess material quickly and surface finish is not too important, a heavy depth of cut with a course feed should be used.
            c. The finishing cut is used to bring the diameter to size and produce a good surface finish and therefore a lighter depth of cut with a fine feed should be used.
            d. If much material must be removed, the roughing cuts should be as deep as possible to reduce the size of the part to within .020" to .030" of the size required.
        2. Lathe feed guidelines

    1. Roughing - .010" to .030" (.25 mm to .75 mm) per revolution
    2. Finishing - .003" to .010" (.07 mm to .25 mm) per revolution
    3. See chart 7.4 in this module
  3. Mill feed guidelines
    a. Inch feed calculation ...
      Feed (ipm) = N x chip per tooth x RPM
      where N = number of teeth on the cut
    b. Metric feed calculation ... feed (mm/min) = same as above
    c. See charts 7.4 and 7.5 in this module
E. Problems related to using the wrong feed
  1. Feed speed too slow
    a. Time will be lost for machining (low production rates)
    b. Broken tool bits
  2. Feed too fast
    a. Cutting tool edge breaks down
    b. Loss in production time due to reconditioning/replacing the tool
F. Student practice using the "Calculate Speeds and Feeds for Machining" exercise and the recommended feed charts found in this module

MFG-B7-LA
Calculate Speeds and Feeds for Machining
Attachment 2: MASTER Laboratory Aid

TABLE 7.1

Lathe Cutting Speeds in Feet & Meters Per Minute Using a High-Speed Toolbit						
Material	**Turning & Boring**				**Threading**	
	Rough Cut		**Finish Cut**			
	ft/min	**m/min**	**ft/min**	**m/min**	**ft/min**	**m/min**
Machine Steel	90	27	100	30	35	11
Tool Steel	70	21	90	27	30	9
Cast Iron	60	18	80	24	25	8
Bronze	90	27	100	30	25	8
Aluminum	200	61	300	93	60	18

TABLE 7.2

Milling Machine Cutting Speeds				
Material	**High-Speed Steel Cutter**		**Carbide Cutter**	
	ft/min	**m/min**	**ft/min**	**m/min**
Machine Steel	70-100	21-30	150-250	45-75
Tool Steel	60-70	18-20	125-200	40-60
Cast Iron	50-80	15-25	125-200	40-60
Bronze	65-120	20-35	200-400	60-120
Aluminum	500-1000	150-300	1000-2000	150-300

TABLE 7.3

Feeds for Various Materials (Using a High-Speed Cutting Tool)				
Materials	**Rough Cuts**		**Finish Cuts**	
	Inches	**Millimeters**	**Inches**	**Millimeters**
Machine Steel	0.010-0.020	0.25-0.50	0.003-0.010	0.07-0.25
Tool Steel	0.010-0.020	0.25-0.50	0.003-0.010	0.07-0.25
Cast Iron	0.015-0.025	0.40-0.65	0.005-0.012	0.13-0.30
Bronze	0.015-0.025	0.40-0.65	0.003-0.010	0.07-0.25
Aluminum	0.015-0.030	0.40-0.75	0.005-0.010	0.13-0.25

TABLE 7.4

Recommended Feed per Tooth (High-Speed Steel Cutters)

Material	Face Mills		Helical Mills		Slotting & Side Mills		End Mills		Form-Relieved Cutters	
	In.	mm	In.	mm	In.	mm	In.	mm	In.	mm
Aluminum	0.022	0.55	0.018	0.45	0.013	0.33	0.011	0.28	0.007	0.18
Brass & Bronze (medium)	0.014	0.35	0.011	0.28	0.008	0.20	0.007	0.18	0.004	0.10
Cast Iron (medium)	0.013	0.33	0.010	0.25	0.007	0.18	0.007	0.18	0.004	0.10
Machine Steel	0.012	0.30	0.010	0.25	0.007	0.18	0.006	0.15	0.004	0.10
Tool Steel (medium)	0.010	0.25	0.008	0.20	0.006	0.15	0.005	0.13	0.003	0.08
Stainless Steel	0.006	0.15	0.005	0.13	0.004	0.10	0.003	0.08	0.002	0.05

TABLE 7.5

Recommended Feed per Tooth (Cemented-Carbide-Tipped Cutters)

Material	Face Mills		Helical Mills		Slotting & Side Mills		End Mills		Form-Relieved Cutters	
	In.	mm	In.	mm	In.	mm	In.	mm	In.	mm
Aluminum	0.020	0.50	0.016	0.40	0.012	0.30	0.010	0.25	0.006	0.15
Brass & Bronze (medium)	0.012	0.30	0.010	0.25	0.007	0.18	0.006	0.15	0.004	0.10
Cast Iron (medium)	0.016	0.40	0.013	0.33	0.010	0.25	0.008	0.20	0.005	0.13
Machine Steel	0.016	0.40	0.013	0.33	0.009	0.23	0.008	0.20	0.005	0.13
Tool Steel (medium)	0.014	0.35	0.011	0.28	0.008	0.20	0.007	0.18	0.004	0.10
Stainless Steel	0.010	0.25	0.008	0.20	0.006	0.15	0.005	0.13	0.003	0.08

MFG-B8-HO
Use Coordinate Systems
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify points using the Cartesian coordinate system;
b. Identify points using the absolute dimensioning system;
c. Identify points using the incremental dimensioning system; and,
d. Identify points using the polar coordinate system.

Module Outline:

I. Identify Points Using the Cartesian Coordinate System
  A. Describe the Cartesian (rectangular) coordinate system - the basis for all machine movement
    1. Define *axis* - any direction of movement on a machine tool. The spindle is always defined as the Z axis on 3 axis systems.
    2. Discuss the plus and minus aspects of an axis
    3. Discuss the quadrants I, II, III, and IV. Note that the signs for the X- and Y-axes change for the different quadrants.
    4. Discuss the concept of three dimensional locations
    5. Discuss how points are described in both 2- and 3-axis systems
    6. Describe how a part fits into the axis system

II. Identify Points Using the Polar Coordinate System
  A. Describe the *polar coordinate system* - a system by which all points are located around a known location (or pole).
    1. Points are usually identified by a known distance from the pole and a given angle from the horizontal (3:00 o'clock position equals zero degrees)
    2. Positive angles are measured from angle zero in a counterclockwise direction
    3. Negative angles are measured from angle zero in a clockwise direction
  B. Student practice

III. Locate Points Using the Absolute Dimensioning System
  A. Define *absolute positioning*- in absolute positioning, all machine locations are taken from one fixed zero (origin) point. This origin point does not change.
  B. This corresponds to the datum dimensioning method used by drafters. In datum dimensioning, all dimensions on a drawing are placed in reference to one fixed zero point.
  C. Student practice

IV. Locate Points Using the Incremental Dimensioning System
    A. Define *incremental positioning*- in incremental positioning, the X0/Y0 moves with each position change. The current position, in fact, becomes the X0/Y0 for the next positioning move.
    B. This corresponds to the delta dimensioning method used by drafters. In delta dimensioning, all dimensions on a drawing are "chain-linked." Each location is dimensioned from the previous one.
    C. Student practice

MFG-B9-HO1
Perform Calculations for Sine Bar and Sine Plate
Attachment 1: **MASTER** Handout No. 1

Objective(s):

Upon completion of this unit the student will be able to:
- a. Calculate gage block build up for 5" sine bar; and,
- b. Calculate gage block build up for 10" sine plate.

Module Outline:

- I. Calculate gage block build up for 5" sine bar
  - A. Definitions
    - 1. Sine bar--a small (usually 5") hinged device of extremely hard metal, milled to tight tolerances, that is used to measure angles of up to 60°
    - 2. Gage block--a block of treated metal, used in groups to determine the angle of the cut on the sine bar or sine plate
  - B. Actual Calculation
    - 1. Show how the trigonometric formula converts to practical application:

      $$\text{Sine of angle} = \frac{\text{Side Opposite}}{\text{Hypotenuse}}$$

      For a 5" sine bar, then:

      $$\text{Sine of angle} = \frac{\text{Gage Block Height}}{5}$$
    - 2. Show the complementary use for measuring angles over 60°
    - 3. Checking tapers with the tangential formula: tan a/2 = TPF/24
    - 4. Gage block calculations using the two-column method
    - 5. Use of a sine bar constants table
  - C. Notes on the care and handling of gage blocks
    - 1. Storage
      - a. In the provided manufacturer's case
      - b. Using preservative oil
    - 2. Wringing—how to put them together properly
    - 3. Minimal handling—body temperature affects accuracy
- II. Calculate gage block build up for 10" sine plate
  - A. Definitions
    - 1. Sine plate—a plate, usually made in multiples of 5", to which the workpiece is attached for measurement.
    - 2. Gage block, same as above
  - B. Actual Calculations
- III. Use of the sine bar and sine plate tables

MFG-B9-HO2
Perform Calculations for Sine Bar and Sine Plate
Attachment 2: MASTER Handout No. 2

Two-Column Gage Block Calculations

This example uses the following gage block set with two .050" wear blocks.

Federal Specification Set #4-88
(Courtesy of Brown & Sharpe Manufacturing Company)

.0625	.078125	.09375	.109375

.100025	.100050	.100075

.1001	.1002	.1003	.1004	.1005	.1006	.1007	.1008	.1009

.101	.102	.103	.104	.105	.106	.107
.108	.109	.110	.111	.112	.113	.114
.115	.116	.117	.118	.119	.120	.121
.122	.123	.124	.125	.126	.127	.128
.129	.130	.131	.132	.133	.134	.135
.136	.137	.138	.139	.140	.141	.142
.143	.144	.145	.146	.147	.148	.149

.050	.100	.150	.200	.250	.300	.350
.400	.450	.500	.550	.600	.650	.700
.750	.800	.850	.900	.950		

1.000	2.000	3.000	4.000

From this gage block set, we will calculate a gage block stack of 2.613 inches, which corresponds to the angle 31° 30'. The two-column method is quick and simple:

1. Subtract the two wear blocks;
2. Beginning with the right-most digit, eliminate the digits; and,
3. Calculate the remaining whole numbers.

Item	Individual Height	Total Height
1. Required Height		**2.613**
2. Wear Blocks (2)	**.050**	**.100**
Remainder		**2.513**
3. Eliminate Rightmost digit	**.113**	**.113**
Remainder		**2.400**
4. Eliminate Rightmost digit	**.400**	**.400**
Remainder		**2.000**
5. Calculate Whole Numbers	**2.000**	**2.000**
Remainder		**0**

By using the two-column method, you will write down the blocks which you need as you calculate the height. To meet the required height, the above chart shows you that you need:

1. Two wear blocks;
2. One .113 block;
3. One .400 block; and,
4. One 2.000 block.

Name:______________________ Date:_______________

MFG-B9-LE

Perform Calculations for Sine Bar and Sine Plate

Attachment 3: MASTER Laboratory Exercise

Using the set of gage blocks provided, solve the following problems. Be sure to demonstrate proper care and use of the gage blocks. Show all calculations for gage block height using the two-column method.

A. Using a 5" sine bar:

1. Set the angle of a cut at 32°.
2. Set the angle of a cut at 77°.
3. Set the angle of a cut at 3°.
4. Set the angle of a cut at 15° 30'.
5. Set the angle of a cut at 22°.

B. Using a 10" sine bar:

1. Set the angle of a cut at 32°.
2. Set the angle of a cut at 77°.
3. Set the angle of a cut at 3°.
4. Set the angle of a cut at 15° 30'.
5. Set the angle of a cut at 22°.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-B10-HO
Calculate for Direct, Simple, and Angular Indexing
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Calculate for direct indexing;
b. Calculate for simple indexing (plain);
c. Calculate for angular indexing; and,
d. Use *Machinery's Handbook* for calculations.

Module Outline:

I. Calculate for direct indexing
  A. Define *direct indexing*: use of the indexing plate, without the worm gear, to obtain consistent angles
  B. Discuss the various plate configurations
  C. Explain the numerator/denominator of derived fractions in relation to the indexing plates and the circles on them
  D. Discuss the uses and limitations of direct indexing
  E. Show calculations based on the example in the student Self-Assessment or one of the sample index plates
    1. Discuss choice of circle on indexing plate
    2. Show possible divisions based on the number of holes in the circle

II Calculate for simple indexing (plain)
  A. Define *simple indexing*: use of the indexing plate, the crank, and the sector arms to obtain consistent angles that are not usually available through direct indexing
  B. Discuss the 40:1 ratio of crank turns to spindle turns
  C. Discuss the use of the indexing plate and sector arms in conjunction with the crank
  D. Show calculations
    1. Simple formula: Indexing = 40/N, where N is the number of divisions to be cut, shows the necessary number of crank turns
    2. Show calculations for indexing plates resulting from fractional crank turns

III. Calculate for angular indexing
  A. Define *angular indexing*: use of degrees instead of divisions to determine the spacing of cuts
  B. Show that one crank turn equals 9° or 540' of arc
  C. Calculations
    1. Indexing = Degrees Required/9

      2. Indexing = Minutes Required/540
      3. 360° x 60'/degree = 21,600' in a circle

IV. Use ***Machinery's Handbook*** for calculations
  A. Discuss the differences between indexing plates from Brown & Sharpe and those of Cincinnati Standard Plate
  B. Show tables of calculations and their uses

MFG-B10-LE
Calculate for Direct, Simple, and Angular Indexing
Attachment 2: MASTER Laboratory Exercise

I. Necessary Materials
A. Rotary table with indexing wheel
B. Dividing head
C. Several different sample pieces already cut by above methods

II. Instructor Demonstration
Using some of the sample pieces, the instructor will demonstrate the use of the dividing head and the rotary table.

III. Student Practice
A. Measure the sample pieces given to you by the instructor
B. Calculate the proper indexing for each piece
C. Set the rotary table and check it against the piece
D. Set the dividing head and check it against the piece
E. You should repeat III.B-D. for each of the types of indexing

MFG-B10-LA
Calculate for Direct, Simple, and Angular Indexing
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-B11-HO
Perform Calculations Necessary for Turning Tapers
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Calculate tail stock offset; and,
- b. Determine unknowns (tpf, small and/or large diameters, etc.) for taper turning.

Module Outline:

- I. Calculate tail stock offset
  - A. Definitions
    - 1. Taper angles
      - a. Included angle: The total angle of the taper measured from *both sides* of the taper
      - b. Angle from center line: The angle of the taper measured from the center line of the workpiece on *one side* of the taper; therefore, one-half the included angle
    - 2. Tpf: Taper per foot, inches of decrease in diameter per foot of taper length
    - 3. Tpi: Taper per inch, inches of decrease in diameter per inch of taper length
    - 4. Metric ratio: 1 millimeter per unit of work length
    - 5. Tail stock offset: The distance from the center of the head stock to the center of the tailstock that is required to cut a taper
  - B. Calculations, where L is the Length of the workpiece; L_T is the Length of the taper; D is the large diameter of the taper; d is the small diameter at the end of the taper; k is amount of taper per unit length; and a is the angle from the center line
    - 1. Offset = (tpi x L)/2
    - 2. Offset = (tpf x L)/24
    - 3. Offset = $[L \times (D-d)]/2L_T$
    - 4. Tan a = tpf/24
    - 5. Metric Offset = $[(D-d)/2L_T] \times L$
    - 6. Metric Taper: $D-d = L_T/k$
- II. Determine unknowns (tpf, small and/or large diameters, etc.) for taper turning using the formulae listed in I.B.

MFG-B11-LA
Perform Calculations Necessary for Turning Tapers
Attachment 2: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
   a. No loose clothing, including ties;
   b. Long hair properly stowed;
   c. No jewelry;
   d. Hard, closed-toe shoes;
   e. Eye protection (safety glasses); and,
   f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-B12-HO1
Calculate Depth of Cut for Round Surfaces
Attachment 1: **MASTER** Handout No. 1

Objective(s):

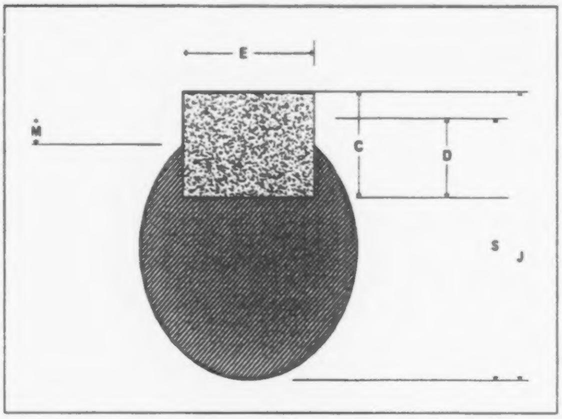
Upon completion of this unit the student will be able to:

a. Calculate depth of cut for flats to be machined on cylindrical pieces; and,
b. Calculate depth of cut for keyways which are machined on cylindrical pieces.

Module Outline:

I. Calculate depth of cut for flats to be machined on cylindrical pieces
II. Calculate depth of cut for keyways which are machined on cylindrical pieces
    A. Definitions
        1. **Broach**: a multi-toothed cutter used to cut irregular internal shapes as well as external features
        2. **Keyseat**: a slot that is designed to accommodate a protrusion (key) cut into a workpiece either internally or externally; sometimes called **keyway**
    B. Discuss the process of keyway broaching
    C. Calculate depth of cut and discuss broach selection
        1. Broaches
            a. Selection
            b. Common problems
        2. ***Machinery's Handbook*** table: "Finding Depth of Keyseat And Distance from Top of Key to Bottom of Shaft"
        3. Keyseat formulae (See **MFG-B12-HO2**)
            a. Cutter Feed Depth: $M + D$
            b. Precision Formula for *M*: $M = \frac{1}{2}(S - \sqrt{S^2 - E^2})$
            c. Non-precision Formula for *M*: $M = E^2/4S$
            d. Verification Formula: $J = [S - (M + D)] + C$

MFG-B12-HO2
Calculate Depth of Cut for Round Surfaces
Attachment 2: MASTER Handout No. 2



MFG-B12HO
Calculate Depth of Cut For Round Surfaces
Reference Handout

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-B13
Use All Functions on a Scientific Calculator
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Name the function keys that are most commonly found on any given "scientific calculator";
b. Enter numbers into a calculator and understand how the scientific calculator displays numbers;
c. Complete addition, subtraction, multiplication, and division operations working with whole numbers, fractions, mixed numbers, decimals, percentages, powers, roots, and trigonometric functions utilizing the scientific calculator;
d. Understand the order of operation(s) of the scientific calculator; and,
e. Use the memory and parentheses functions of a scientific calculator to solve simple formulas.

Module Outline:

I. Introduction to the Scientific Calculator
    A. Explanation of the function keys that are most commonly found on any given "scientific calculator"
    B Explanation of how to enter numbers into a scientific calculator and of how the calculator displays numbers
II. Using the Scientific Calculator
    A. How to add, subtract, multiply, and divide whole numbers, fractions, mixed numbers, decimals, percentages, powers, roots, and trigonometric functions
    B. Introduction to the order of operation(s)
    C. How to use the memory and parenthetical functions to solve simple formulas

MFG-B14-HO
Solve Static Systems For Resultant Force
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this module, the student will:

a. Know the difference between weight and mass;
b. Understand the basics of vector mathematics and torque equations;
c. Understand the units of mechanical forces; and,
d. Use mathematics to predict resultant force from multiple vectors.

Module Outline:

I. Mass vs. Weight
  A. Mass is constant.
  B. Weight varies by location.
  C. Weight is dependent on both mass and gravity.
II. Units of Mechanical Force
  A. English pound-foot
  B. SI Newton-meter
  C. Fractional units of both systems
III. Vectors and Torque
  A. *Vector:* a physical quantity having both direction and magnitude
  B. *Torque:* a force applied to a lever arm on an axis of rotation
  C. *Scalar:* a physical quantity having only magnitude
IV. Mathematics of Force
  A. Adding and Subtracting collinear forces
  B. Adding and Subtracting oblique forces
  C. Torque Solutions
  D. Stress that force is a vector, ***not*** a scalar

MFG-B15-HO
Determine Strength of Materials For Various Applications
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module, the student will be able to:

a. Recognize the basic types of material strengths;
b. Recognize the types of simple physical stresses to which materials are subjected; and,
c. Determine the strength of a given material in relation to the appropriate physical stress.

Module Outline:

- I. Stress and Deformation
  - A. Factors affecting strengths
    - 1. Temperature
    - 2. Time element
      - a. Static
      - b. Impact
      - c. Cyclic
    - 3. Corrosive vapors or liquids
    - 4. Pressure differential
  - B. Types of simple stresses
    - 1. Direct tension
    - 2. Direct compression
    - 3. Bending
    - 4. Direct shear
    - 5. Torsion
- II. Properties of Materials
  - A. Yield strength (S_y)
  - B. Ultimate (tensile) strength (S_u)
  - C. Modulus of elasticity (Young's Modulus) (E)
  - D. Poisson's ration (μ)
  - E. Compression
    - 1. Compressive yield strength (S_{cy})
    - 2. Compressive ultimate strength (S_{cu})
  - F. Shear
    - 1. Shear yield strength (S_{sy})
    - 2. Shear ultimate strength (S_{su})
    - 3. Modulus of rigidity (G)
  - G. Fatigue
- III. Moments of Inertia

- A. Simple forms
  - 1. Solid square cross-section
  - 2. Hollow square cross-section
  - 3. Solid rectangular cross-section
  - 4. Hollow rectangular cross-section
  - 5. Solid circular cross-section
  - 6. Hollow circular cross-section
  - 7. Standard I-beam (flange slope of 1/6)
- B. Breaking down complex forms into simple forms
- C. Combining results for calculation

IV. Use of ***Machinery's Handbook***

V. Problems of Torque

VI. Calculate Simple Stresses

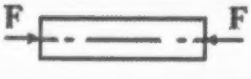
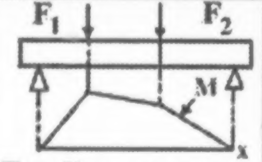
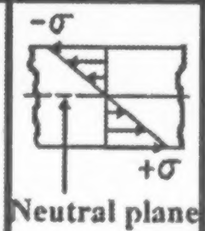
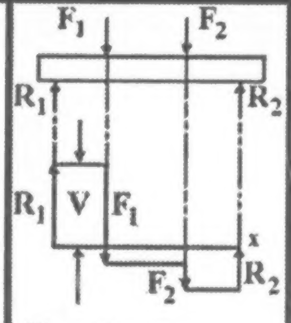
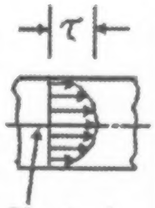
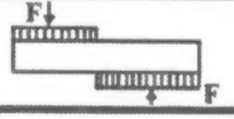
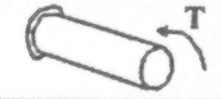
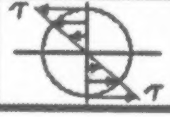
- A. Definitions (from ***Machinery's Handbook***)
  - 1. A is the cross-sectional area in square inches
  - 2. F is the external force in pounds
  - 3. I is the moment of inertia in inches^4
  - 4. J is the polar moment of inertia in inches^4
  - 5. M is the bending moment in inch-pounds
  - 6. T is the torsional moment in inch-pounds
  - 7. V is the shearing force in pounds
  - 8. Z is the section modulus in inches^3
  - 9. Z_p is the polar section modulus in inches^3
  - 10. σ is the simple normal stress in pounds per inch^2
  - 11. τ is the simple shear stress in pounds per inch^2
- B. Direct tension
- C. Direct compression
- D. Bending
  - 1. General
  - 2. Rectangular beams
  - 3. Solid circular beams
- E. Direct shear
- F. Torsion

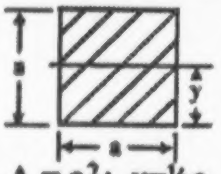
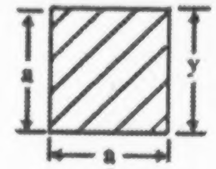
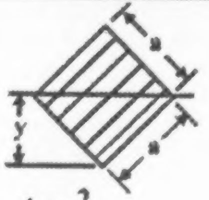
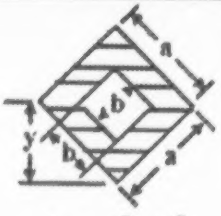
VII. Design of Joints

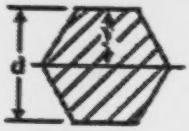
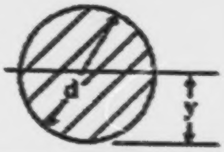
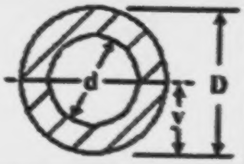
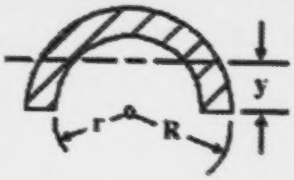
- A. Load
- B. Length
- C. Supports
- D. Shape of joined members

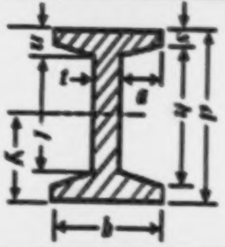
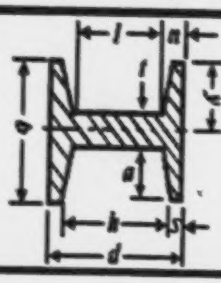
VIII. Fastening Techniques

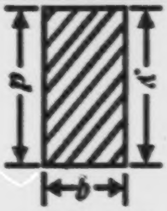
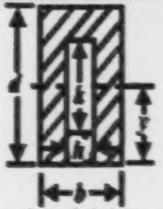
MFG-B15RS
Determine Strength of Materials For Various Applications
Attachment 2: MASTER Reference Sheet

Case	Type of Loading	Illustration	Stress Distribution	Stress Equations
1	**Direct tension**		Uniform	$\sigma = \frac{F}{A}$ (9)
2	**Direct Compression**		Uniform	$\sigma = -\frac{F}{A}$ (10)
3	**Bending**	 Bending moment diagram	 $-\sigma$ $+\sigma$ Neutral plane	$\sigma = \pm\frac{M}{Z} = \pm\frac{My}{I}$ (11)
4	**Bending**	 F_1 F_2 R_1 R_2 R_1 V F_1 x F_2 R_2 Shearing force diagram	 τ Neutral Plane	For beams of rectangular cross-section: $\tau = \frac{3V}{2A}$ (12) For beams of solid circular cross-section: $\tau = \frac{4V}{3A}$ (13) For wide flange and I beams (approximately): $\tau = \frac{V}{a}$ (14)
5	**Direct shear**		Uniform	$\tau = \frac{F}{A}$ (15)
6	**Torsion**			$\tau = \frac{T}{Zp} = \frac{Tc}{J}$ (16)

Section **A = area** **y = distance from axis to extreme fiber**	**Moment of Inertia** **I**	**Section Modules** $Z = \frac{I}{y}$	**Radius of Gyration** $k = \sqrt{\frac{I}{A}}$
 $A = a^2; \; y = \frac{1}{2}a$	$\frac{a^4}{12}$	$\frac{a^3}{6}$	$\frac{a}{\sqrt{12}} = 0.289a$
 $A = a^2; \; y = a$	$\frac{a^4}{3}$	$\frac{a^3}{3}$	$\frac{a}{\sqrt{3}} = 0.577a$
 $A = a^2$ $y = \frac{a}{\sqrt{2}} = 0.707a$	$\frac{a^4}{12}$	$\frac{a^3}{6\sqrt{2}} = 0.118a^3$	$\frac{a}{\sqrt{12}} = 0.289a$
 $A = a^2 - b^2$ $y = \frac{a}{\sqrt{2}} = 0.707a$	$\frac{a^4 - b^4}{12}$	$\frac{\sqrt{2}\,(a^4 - b^4)}{12a}$ $= 0.118\,\frac{a^4 - b^4}{a}$	$\sqrt{\frac{a^2 + b^2}{12}}$ $= 0.289\sqrt{a^2 + b^2}$

Section	Area of Section, A	Distance from Neutral Axis to Extreme Fiber, y
	$\frac{3d^2 \tan 30°}{2} = 0.866d^2$	$\frac{d}{2}$
	$\frac{\pi d^2}{4} = 0.7854d^2$	$\frac{d}{2}$
	$\frac{\pi(D^2 - d^2)}{4}$ $= 0.7854(D^2 - d^2)$	$\frac{D}{2}$
	$\frac{\pi(R^2 - r^2)}{2}$ $= 1.5708(R^2 - r^2)$	$\frac{4(R^3 - r^3)}{3\pi(R^2 - r^2)}$ $= 0.424\ \frac{R^3 - r^3}{R^2 - r^2}$

Section	Area of Section, A	Distance from Neutral Axis to Extreme Fiber, y
	$dt+2a(s+n)$	$\frac{d}{2}$
	$dt+2a(s+n)$	$\frac{b}{2}$

A=area y= distance from axis to extreme fiber	**Moment of Inertia I**	**Section Modulus $Z=\frac{I}{y}$**	**Radius of Gyration $k=\sqrt{\frac{I}{A}}$**
 A=bd; y=d	$\frac{bd^3}{3}$	$\frac{bd^2}{3}$	$\frac{d}{\sqrt{3}}=0.577d$
 A = bd-hk $y=\frac{1}{2}d$	$\frac{bd^3-hk^3}{12}$	$\frac{bd^3-hk^3}{6d}$	$\sqrt{\frac{bd^3-hk^3}{12(bd-hk)}}$ $=0.289\sqrt{\frac{bd^3-hk^3}{bd-hk}}$

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

Duties	Tasks												
A Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
	B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

1240

DutyC

1250

MFG-C1-HO1
Identify Basic Layout of Drawings
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Identify types of lines within a drawing;
- b. List the essential components found in the title block;
- c. Locate bill of materials in a drawing; and,
- d. List the components found in the revision block.

Module Outline:

- I. Identify Types of Lines Within a Drawing
  - A. Break
    - 1. **Short**: a generally freehand, heavy, wavy line; indicating that the part is continuous and unchanged between the lines
      - a. Square break
      - b. Solid, round break
      - c. Hollow, round break
    - 2. **Long**: a thin line broken by zig-zags indicating that the part is continuous and unchanged between the lines
  - B. Center Lines
    - 1. A thin, broken line composed of alternating long and short lines, evenly spaced
    - 2. Uses
      - a. To show the center of a circle, arc, or part
      - b. To show that a part is bilaterally symmetrical. Used in conjunction with three parallel lines at each end
      - c. To indicate motion in conjunction with phantom lines
  - C. Cutting Plane
    - 1. A heavy, broken line whose ends, which have arrowheads pointed in the direction of the drawing, are perpendicular to the body of the line. Sometimes shown as one long and two short alternating lines.
    - 2. To indicate an imaginary cut through a piece; this line may be offset
  - D. Dimension Lines
    - 1. Thin, solid lines having arrowheads at both ends. The center is left open for dimensional specifics.
    - 2. Show the size of the piece relative to the line's direction
  - E. Extension Lines

    1. Thin, solid lines visibly removed from the edge to which they refer
    2. Used in conjunction with dimensions lines to show the sizes of objects

F. Hidden (Invisible) Lines
    1. Thin, evenly broken line
    2. Used to delineate any feature not visible in the particular view

G. Leader
    1. Thin, solid line with one arrowhead (when ending on an edge) or a dot (when ending on a surface) at one end and a bend that changes the line's direction at the other
    2. To annotate the drawing

H. Object (Visible) Lines
    1. Very heavy, solid lines
    2. Demarcates edges, surfaces, and corners in the visible view

I. Phantom Lines
    1. Thin line composed of one long and two short, equally spaced parts
    2. Uses
        a. Indicate alternate positions
        b. Demonstrate mating surfaces
        c. Show repetitious details

J. Screw Threads
    1. Three methods
        a. Actual drawing (seldom used)
        b. Schematic representation
        c. Simplified representation
    2. To display threading on parts. When marked with a "B" indicates a bore or internal thread.

K. Section
    1. Thin, solid lines, usually at a definite angle to the horizontal
    2. To indicate that the view has been cut off from the main part or that the part has been cut in two
    3. Sometimes used to identify specific materials

J. Precedence of Lines: On occasion, lines in a drawing may be superimposed. When this occurs, the lines are shown in the following order; e.g., visible lines are shown instead of any others; etc.
    1. Visible (Object) line
    2. Hidden (Invisible) line
    3. Cutting plane line
    4. Center line
    5. When either a visible or a hidden line occludes a center line, the ends of the center line are detached from the *outside* edge of the part

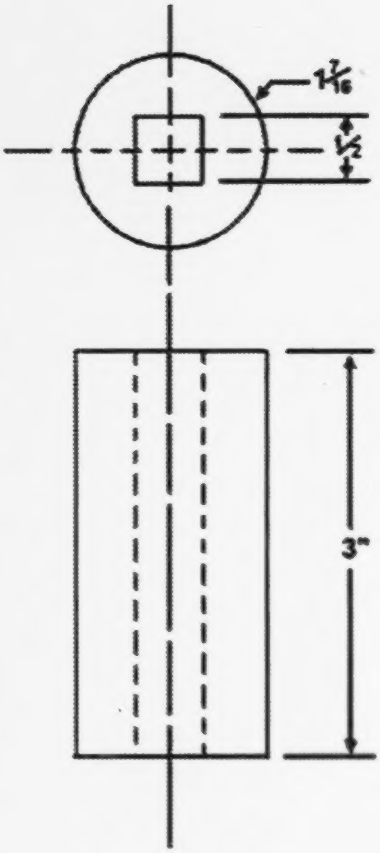
II. List the Essential Components Found in the Title Block--note That Title Blocks Are Not Fully Standardized and That Their Contents May Vary from Company to Company
  A. The title block is usually found in the lower right-hand corner.
  B. Components
    1. Name and address of the manufacturer or designer
    2. *Title* or brief description of parts
    3. *Part Number* identifying the specific part
    4. *Drawing Number* identifying the specific *drawing*
    5. *Drawn by/Date* shows the drafter and the date of the drawing's completion
    6. *Checked by/Date* shows the drawing's inspector and the date of approval
    7. *Replaces* lists a part number that the new part will supersede
    8. *Replaced by* lists a part that supersedes the part in the drawing. If the drawing is the most current, there will be a slash through this block.
    9. *Scale* shows the proportion of the drawing to life
      a. *Full* indicates that the drawing is life-sized
      b. *Half* indicates that the drawing is one-half life size *in each dimension*
    10. *Page* shows both the current page, *p*, and the total number of pages, *t*, in this format: *p of t*
    11. *Tolerances* show the size limits of dimensions that are not specifically dimensioned in the drawing. These general tolerances are always secondary to tolerances listed in the drawing
    12. *Heat Treatment* shows the required heat treatment and hardness specifications. If there are no specifications, then the box says NONE.
    13. *Material* shows the exact material from which the part must be made
    14. *Finish* indicates the general surface finish of the completed part
    15. *Code Identification Number* identifies the specific manufacturer or design group. The number is provided by the Federal Government.
    16. *Size* shows the physical size of the draft paper
    17. The word NOTED in any block means that the information is supplied in the body of the drawing at or near the relevant item

III. Locate Bill of Materials in a Drawing: The Materials List Is Usually Located Immediately above the Title Block.

IV. List the Components Found in the Revision Block
  A. *Zone* refers to area which is to be changed. Large drawings generally have an alphanumeric coordinate system for clarity.

B. *Revision* specifies the exact change in the part. It is identified by a letter.
C. *Description* contains a brief description of the revision
D. *Date* is the effective date of the revision
E. *Apvd* abbreviates Approved. This is the identification of the inspector who approved the changes.

MFG-C1-HO2
Identify Basic Layout of Drawings
Attachment 2: **MASTER** Handout



SQUARE HOLE IN A ROUND PEG			
PART NO.	1010106	DRAWING NO.	A1576B
CHECKED BY	R. van Rijn	10/31/97	
REPLACES	A. Rand	11/14/97	
SCALE	1010071	REPLACED BY	———
TOLERANCES	±1/64	PAGE	1 of 1
MATERIAL	Plutonium	FINISH	RMS

MFG-C2-HO
Identify Basic Types of Drawings
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify orthographic views;
b. Identify positions of views (top, front, side, and auxiliary);
c. Visualize one or more views from a given view;
d. Identify isometric views;
e. Identify exploded isometric drawings; and,
f. Identify assembly drawings.

Module Outline:

I. Identify Orthographic Views
    A. Characteristics of orthography: all views perpendicular to the viewer; no vanishing points
    B. Review the *projection planes*
II. Identify Positions of Views
    A. Top
    B. Front
    C. Side
    D. Auxiliary
III. Visualize One or More Views from a Given Angle
IV. Identify Isometric Views: All Angles at the Reference Origin Are 120°
V. Identify Exploded Isometric Drawings
VI. Identify Assembly Drawings

MFG-C3-HO
Review Blueprint Notes and Dimensions
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Explain basic blueprint terminology;
b. Identify the types of dimensions;
c. Identify general note symbols;
d. Locate notes on a print;
e. Interpret commonly used abbreviations and terminology;
f. Determine tolerances associated with dimensions on a drawing;
g. Determine the tolerance for a reference dimension;
h. Determine the surface finish for a given part; and,
i. List the essential components found in the general drawing notes.

Module Outline:

I. Explain Basic Blueprint Terminology
  A. Print Definitions
    1. **Print**: an exact copy of an engineering drawing
    2. **Engineering drawing:** the original design of anything as drawn by the drafter
  B. Print Parts and Terms
    1. **Title Block**: an area for the controlling information of a document, usually set apart in the lower right-hand corner
    2. **Print Body**: the actual drawing of the item, normally consisting of several views
    3. **View**: the angle of observation of the artist, usually the top, front, and right side of the item
    4. Projections
      a. **Orthographic**: all views are perpendicular to the drafter's field of vision, lacks vanishing points
      b. **Isometric**: built around a central point whose radiant axes are equally spaced at 120°
      c. Other **Axonometric** Views: briefly discuss other views, such as diametric
    5. Angles of Projection
      a. **First Angle Projections** are usually European and SI
      b. **Third Angle Projections** are North American and either SI or SAE

II. Identify the Types of Dimensions
  A. Physical Dimensions

1. **Linear** dimensions show height, width, and length as direction along a straight line
2. **Angular** dimensions display the sizes of angular features
    a. **Angle of the arc** is size of the actual angle, usually in degrees
    b. **Length of the arc** measures the size of a rounded feature along the rounded edge. This is usually a reference dimension.
    c. **Length of the chord** is the direct distance between the end points of the arc
3. **Radial dimensions** display the size of radii (the plural of radius). Discuss *shortened radii* and *true* and *spherical radii.*
4. **Coordinate dimensions** all begin at a particular point known as a *datum point*
    a. **Rectangular** coordinate dimensions start at some arbitrary datum point 0,0 and are noted in a Cartesian plane
    b. **Polar** coordinate dimensions start at some arbitrary datum point 0,0 and are noted in lengths of radii and angles of arcs
5. **Tabular** dimensions establish a table of references with a key that is tied to a drawing. This method reduces confusion by eliminating clutter in the body of the drawing.

B. Engineering Dimensions Conventions
1. Usually placed in the area that best shows the feature
2. Use of *dimension lines, leader lines,* and *extension lines*
3. **Working** dimensions are those used to control the size of the part
4. **Reference** dimensions are those used to contribute useful, but not essential, information to the machinist
5. **In-process** dimensions show the size of the part after a specific machine process, such as milling, but not the final size of the part. These dimensions are noted as such.
6. **Scale** shows the size of the drawing relative to the size of the part
7. **Tolerances** may be in the title block or noted in the drawing

C. Placement of Dimensions
1. **Chaining** shows the relationships between the details of features in a series; sometimes called *incremental dimensioning*
2. **Datum** dimensioning shows the details of features in relation to an arbitrary datum point 0,0; also called *absolute* or *base-line* dimensioning

3. **Direct** dimensioning shows the relationship between two features where that relationship is completely independent of the rest of the part

III. Identify General Note Symbols

IV. Identify item number symbols

A. Angular symbols

1. ° indicates degrees
2. ' indicates minutes
3. " indicates seconds
4. D or DIA indicates diameter
5. R or RAD indicates radius

B. Linear symbols

1. ' indicates feet
2. " indicates inches
3. Metric linear abbreviations are not symbolic; they are alphabetical abbreviations. Discuss mm, cm, etc.

V. Locate Notes on a Print

A. Dimensional: give specific values to sizes. Discuss conventions on *dual unit dimensioning.*

B. Process

C. Detail

D. Single-view

E. Thickness

VI. Interpret Commonly Used Abbreviations and Terminology

VII. Determine Tolerances Associated with Dimensions on a Drawing

A. Discuss the differences in *standard* or *customary* tolerances and *specific* tolerances

B. Discuss linear tolerance and radial tolerance

VIII. Determine the Tolerance for a Reference Dimension

IX. Determine the Surface Finish for a Given Part

A. Definitions

1. **Roughness**: the fine, irregular ridges/troughs caused by the finishing machine
2. **Waviness**: the large, irregular ridges/troughs caused by the finishing machine. Roughness rides the surface of waviness.
3. **Lay**: the predominant direction of the marks in the surface finish
4. **Waviness Spacing:** the distance between the peaks of two adjacent ridges in the waviness
5. **Waviness Height:** measured within a single waviness spacing, specifies the distance between the higher peak and the bottom of the trough
6. **Roughness Spacing:** similar to waviness spacing, the distance between two adjacent peaks in the waviness

7. **Roughness Sampling Length:** the length of an arbitrary sample of the roughness, used to determine the roughness average
8. **Roughness Average:** the mathematical average of the roughness of a surface within a *roughness sampling length*, measured from a center line and measured in micro inches
9. Lay Symbols:
    a. **Angular lay:** lay runs in two mutually perpendicular directions that are set at an angle that is oblique to the reference line
    b. **Circular lay:** lay is basically circular around the center of the surface
    c. **Multi-directional lay:** lay has no predominant direction
    d. **Parallel lay:** lay is parallel to the reference line
    e. **Particulate lay:** lay has no direction, is protuberant, or particulate
    f. **Perpendicular lay:** lay is perpendicular to the reference line
    g. **Radial lay:** lay is basically radial through the center of the surface

B. Basic and variant surface texture symbols
1. Basic checkmark with roughness indicators--maximum only and maximum/minimum values
2. Finish removal triangular checkmark with removal value
3. Already finished checkmark with tangential circle

X. List the Essential Components Found in the General Drawing Notes

MFG-C4-HO
List the Purpose of Each Type of Drawing
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify the purpose of orthographic (3 views) drawings;
b. Identify the purpose of isometric drawing;
c. Identify the purpose of exploded isometric drawing; and,
d. Identify the purpose of assembly drawings.

Module Outline:

NB: The Self-Assessment for this module is greatly dependent on the engineering drawings presented. Therefore, the instructor must complete the questions for the Self-Assessment. The editors strongly recommend a minimum of twenty questions for this module.

I. Identify the Purpose of Orthographic Views
  A. Any orthographic drawing must have a minimum of two views in order to show an object completely.
  B. The top view may be referred to as the plan view. The front or side views may be referred to as the elevations views.
II. Identify Positions of Views (Top, Front, Side, and Auxiliary)
  A. Top, is usually to the left and at the top of the print when viewing a single object, and represents the objects top if you were looking down at it.
  B. Front is directly below the top view, and on the same center line as the top. The front does not necessarily mean the actual front of the object.
  C. Side or sometimes referred as the right side is normally the right side of the front view and is on the same center lines as well as the same elevation.
III. Visualize One or More Views from a Given View
  A. In any given view the student can visualize more then one side of a object. The object can be shown in one of many positions.
IV. Identify Isometric Views
  A. Any object can be drawn from four different directions isometrically, but there is usually one view that best shows the object.
  B. When using isometrics the student should be familiar with the isometric axes, and the term preferred north and alternate north.
  C. In the isometric format, the lines of the object remain parallel and the object is drawn about the three isometric axes that are 120° degrees apart which is at 30° from the plane of the drawing.

D. Isometrics distort dimensions; therefore, you cannot draw isometrics to scale.

V. Identify Exploded Isometric Drawings

A. An *exploded drawing* is a picture of an assembly of several parts drawn isometrically to show the proper steps in assembling a unit.

VI. Identify Assembly Drawings

A. *Assembly drawings* are drawings in which the various parts of an object are shown in their relative positions in the completed unit.

B. Assembly drawings are also used:

1. To illustrate the proper working relationships of the mating parts of an object and the function of each.
2. To show a general idea of how the finished product should look.
3. To assist in securing overall dimensions and center lines in assembly.
4. To give the machinist data needed to design the smaller units of a larger object
5. To provide illustrations which may be used for maintenance manuals or other purposes.

MFG-C5-HO
Verify Drawing Elements
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:
a. Recognize out-of-date blueprints;
b. Check for revisions; and,
c. Determine the scale of the view or section.

Module Outline:

I. Recognize Out-of-Date Blueprints
  A. Check title block for date of completion (*Drawn By*)
  B. Check title block for date of certification (*Checked By*)
  C. Check title block for discontinuation (*Replaced By*)
  D. Check title block for what the new drawing replaces (*Replaces*)
II. Check for Revisions
  A. Revisions are usually listed in a separate block
  B. Revision (change) lists usually contain the following blocks:
    1. **Zone** (on large drawing sheets) shows the area of the revision, using an alphanumeric Cartesian plane
    2. **Revision** shows the exact location of the revision, usually by an alphabetic indicator
    3. **Description** gives a brief description of the change, such as a size change, a new part, or an angular cut difference
    4. **Date** indicates the date the revision was approved and became effective
    5. **Approved By** usually abbreviated, this block shows the person who approved the individual change
III. Determine the Scale of the View or Section
  A. Check the title block for the overall scale of the drawing
  B. Each detail view must be checked for scale
  C. Notes on scale
    1. **Full** or **1:1**--the part is drawn to its actual size
    2. **Half** or **1/2:1**--the part is drawn to one-half its actual size
    3. Any other scale would be distinctly noted
IV. The Word *Noted* in Any Block Indicates That the Desired Information Can Be Found Written Somewhere on the Drawing, Usually Very Close to the Area to Which it Applies

MFG-C6-HO
Practice Geometric Dimensioning and Tolerancing (GD&T)
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify the purpose of GD&T;
b. Identify symbols for controlling location (or true position) of part features;
c. Identify symbols for controlling form (or alignment) of part features;
d. Identify symbols for showing datums and basic dimensions on drawings; and,
e. Identify symbols for Maximum Material Size (MMS) and Regardless of Feature Size (RFS).

Module Outline:

I. Identify the Purpose of GD&T
In industry today, there are many companies competing for replacement parts to replace ones that have worn out. They are geared more towards, and can handle, part replacement better than the companies that made the original unit. Realizing this, manufacturers and the engineering community have used Geometric Dimensioning and Tolerancing to maintain replacement part unity. For example, a part for your car was originally made by Mammoth Motor Company; but when you go to a parts house, they supply you with a part from Acme Auto Parts.

II. Identify Symbols for Controlling Location (Or True Position) of Part Features
True position, Concentricity, and *Symmetry* are used to indicate location control. Many units have a particular bolt pattern; if you were to replace one of the two units with another unit made from a different manufacturer, it may not have the same bolt pattern and would not be compatible.

III. Identify Symbols for Controlling Form (Or Alignment) of Part Features
Perpendicularity (squareness) is one example of form that must be controlled during manufacturing. The following list of symbols indicate types of form control:

1. Straightness;
2. Flatness;
3. Angularity;
4. Parallelism;
5. Roundness;
6. Cylindricity
7. Profile of any line;
8. Profile of any surface; and,

        9. Runout (circular or total).

IV. Identify Symbols for Showing Datums and Basic Dimensions on Drawings
    Datums are reference points, lines, and planes taken to be exact for the purposes of calculation and measurement. They are placed in a rectangular frame and are identified by single or double letters. I, O, and Q are not used.

V. Identify Symbols for Maximum Material Condition (MMC) and Regardless of Feature Size (RFS)
    A. (MMC) refers to the maximum amount of material remaining.
    B. (RFS) refers to means that the form or position tolerance of a feature must be met no matter what the feature size is.

MFG-C7-HO
Analyze Bill of Materials (BOM)
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Know which components are found on BOM;
b. Determine which materials are needed to produce the part;
c. Determine the quantities necessary to produce the part;
d. Submit a completed stock request form as required; and,
e. Submit a completed tool request form as needed.

Module Outline:

I. Discuss Components Found on BOM
  A. Item or Part Number, relative to the body of the drawing
  B. Description of Item
  C. Specification
  D. Material Needed
  E. Number Required
II. Determine Materials Needed to Produce the Part
III. Determine Quantities Necessary to Produce the Part
IV. Submit Completed Stock Request Form as Required
  This topic is company-specific and must be designed at such level. The instructor is encouraged to be extremely general in comments, covering only those areas of stock requests that are universal in application.
V. Submit Completed Tool Request Form as Needed
  Here, too, the instructor must generalize and emphasize that s/he is generalizing.

MFG-C8-HO
Describe the Relationship of Engineering Drawings to Planning
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:
- a. Discuss production schedules;
- b. Understand Material Resource Planning (MRP);
- c. Recognize and utilize inventory control records; and,
- d. Recognize and follow specific shop floor routing documents.

Module Outline:

- I. Discuss Production Schedule
  - A. Internal Factors
    - 1. Available personnel and equipment
    - 2. Priority
    - 3. Setup time
    - 4. Parts per man-hour (quotas)
    - 5. Warehouse to shop floor time for stock
    - 6. Shop floor to shipping department time for parts
  - B. External factors
    - 1. Customer deadlines
    - 2. Material delivery schedules
- II. Discuss Material Resource Planning (MRP)
  - A. Volume of production
  - B. Required stock
    - 1. Types of stock needed
    - 2. Amounts of stock needed
  - C. Waste management
  - D. Mechanical management
    - 1. Tool wear and replacement
    - 2. Machine down-time
- III. Discuss Inventory Control Records
  - A. Receipt of goods documents
  - B. Waste management documents
  - C. Return of goods documents
  - D. Tool room accounts and documents
  - E. Machine time documents
- IV. Discuss Shop Floor Routing Documents

  These documents vary in detail from shop to shop. The instructors should use documents from their own shops to explain both the theory and practice of routing documents.

MFG-C9-HO
Understand and Use Quality Systems
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. **Understand and apply quality principles, including continuous improvement; and,**
- b. **Document paper trails for part revisions.**

Module Outline:

- I. Understand and Apply Quality Principles, Including Continuous Improvement
  - A. **Tolerances as basic quality control**
  - B. **The machinist as the first line of excellence**
  - C. **Specific systems**
    These systems are diverse. You, as the instructor, must tailor this portion of the lecture to the system used in your circumstances.
  - D. **The inspector as guarantor**
  - E. **The consumer: the ultimate judge of top quality**
- II. ISO 9000
  - A. Purpose
  - B. What is ISO 9000?
  - C. How does is work?
  - D. Where do the standards come from?
  - E. Who uses this stuff, anyway?
- III. Document Paper Trails for Part Revisions

MFG-C10-HO
Verify Standard Requirements
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Discuss the purpose of standards; and,
b. Discuss source locations for standards.

Module Outline:

I. Discuss the Purpose of Standards
    A. What are standards, anyway?
    B. Why have standards at all?
    C. How does a technician use today's standards?
    D. The technician's role in quality as it relates to standards.
II. Discuss Source Locations for Standards
    A. Shop/company sources—*Machinery's Handbook*, especially
    B. Industry sources
    C. Governmental sources
III. Oral Shorthand—Nominal Sizes vs. Actual Sizes

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

Duties		Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MFG-D1-HO1
Identify Materials with Desired Properties
Attachment 1: MASTER Handout No. 1

Objective(s):

Upon completion of this unit the student will be able to:

a. Discuss classification system for metals; and,

b. Describe general characteristics for carbon steels, tool steels, stainless steels, structural steels, cast irons, aluminum, and other commonly used metals.

Module Outline:

I. Discuss the Physical Properties of Metal
  A. Brittleness - the property of a metal which permits no permanent distortion before breaking
  B. Ductility - the ability of the metal to be permanently deformed without breaking
  C. Elasticity - the ability of a metal to return to its original shape after any force acting upon it has been removed
  D. Hardness - the resistance to forcible penetration
  E. Malleability - the property of a metal which permits it to be hammered or rolled into other sizes and shapes
  F. Tensile strength - the maximum amount of pull that a material will withstand before breaking
  G. Toughness - the property of a metal to withstand shock or impact
II. Discuss the Classification System for Steel
  A. Carbon steels
    1. Low carbon steel - contains from 0.02 to 0.20 percent of carbon
    2. Medium carbon steel - contains from 0.30 to 0.60 percent of carbon
    3. High carbon steel (tool steel) - contains over 0.60 percent of carbon
  B. Alloy steels - alloying elements allow steels to possess special characteristics
    Discuss Table 1.1 "Effects of Alloying Elements on Steel"
    Discuss Table 1.2 "SAE-ANSI Numerical Designation of Alloy Steels"
III. Describe General Characteristics For:
  A. Carbon Steels
  B. Tool Steels
  C. Stainless Steels
  D. Structural Steels
  E. Cast Irons

F. Non-Ferrous Metals

1. Aluminum and Its Alloys
2. Copper and Its Alloys
3. Nickel Alloys
4. Precious Metals
5. Others

MFG-D1-HO2
Identify Materials With Desired Properties
Attachment 2: MASTER Handout No. 2

TABLES FOR MFG-D1 — PROPERTIES OF METALS
TABLE 1.1

THE EFFECT OF ALLOYING ELEMENTS ON STEEL

EFFECT	ELEMENT											
	Carbon	Chromium	Cobalt	Lead	Manganese	Molybdenum	Nickel	Phosphorus	Silicon	Sulfur	Tungsten	Vanadium
Increases tensile strength	X	X			X	X	X					
Increases hardness	X	X										
Increases wear resistance	X	X			X		X				X	
Increases hardenability	X	X			X	X	X					X
Increases ductility					X							
Increases elastic limit		X				X						
Increases rust resistance		X					X					
Increases abrasion resistance		X			X							
Increases toughness		X				X	X					X
Increases shock resistance		X					X					X
Increases fatigue resistance												X
Decreases ductility	X	X										
Decreases toughness			X									
Raises critical temperature		X	X								X	
Lowers critical temperature					X		X					
Causes hot shortness										X		
Causes cold shortness								X				
Imparts red hardness			X			X					X	
Imparts fine grain structure					X							X
Reduces deformation					X		X					
Acts as deoxidizer					X				X			
Acts as desulphurizer					X							
Imparts oil hardening properties		X			X	X	X					
Imparts air hardening properties					X	X						
Eliminates blow holes								X				
Creates soundness in casting									X			
Facilitates rolling and forging					X				X			
Improves machinability				X						X		

MFG-D1-HO3
Identify Materials With Desired Properties
Attachment 3: MASTER Handout No. 3

TABLE 1.2

SAE-AISI NUMERICAL DESIGNATION OF ALLOY STEELS
(X Represents Percent of Carbon in Hundredths)

Carbon Steels	
Plain carbon	10xx
Free-cutting, resulfurized	11xx
Manganese Steels	13xx
Nickel Steels	
.50% nickel	20xx
1.50% nickel	21xx
3.50% nickel	23xx
5.00% nickel	25xx
Nickel-Chromium Steels	
1.25% nickel, .65% chromium	31xx
1.75% nickel, 1.00% chromium	32xx
3.50% nickel, 1.57% chromium	33xx
3.00% nickel, .80% chromium	34xx
Corrosion and heat-resisting steels	303xx
Molybdenum Steels	
Chromium	41xx
Chromium-nickel	43xx
Nickel	46xx and 48xx
Chromium Steels	
Low-chromium	50xx
Medium-chromium	511xx
High-chromium	521xx
Chromium-Vanadium Steels	6xxx
Tungsten Steels	7xxx and 7xxxx
Triple-Alloy Steels	8xxx
Silicon-Manganese Steels	9xxx
Leaded steels	11Lxx (example)

MFG-D2-HO
Identify Materials and Processes to Produce a Part
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Briefly describe and list the advantages and disadvantages for each of the following: casting processes, hot working processes, and cold working processes;
b. Discuss service requirements (strength, hardness, etc.);
c. Discuss fastening processes (fasteners, welding, bonding, etc.); and,
d. Discuss corrosion resistance methods.

Module Outline:

I. Describe Casting Processes
  A. Discuss the following casting processes: sand, evaporative, shell molding, permanent mold, centrifugal, investment, and die casting
  B. Discuss pattern and mold design factors for each of the above casting processes
  C. List the advantages and disadvantages of the casting processes
II. Describe Hot Working Processes
  A. Discuss the following hot working processes: rolling, strand casting, forging, drawing, extrusion, spinning, and roll forming
  B. List the advantages and disadvantages of the hot working processes
III. Describe Cold Working Processes
  A. Discuss the following cold working processes: rolling, blanking, pressing, drawing, extruding, wire and bar drawing, bending, shearing, and roll forming
  B. List the advantages and disadvantages of the cold working process
IV. Evaluate Alternative Manufacturing Processes
  A. Discuss the powder metallurgy process (PM)
  B. Discuss the following nontraditional machining processes: EDM, laser machining, ultrasonic machining, hydrojet machining, electron beam machining, and plasma beam machining

MFG-D3-HO
Describe the Heat Treating Process
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:
a. Discuss the reasons for heat treating;
b. Discuss the time/temperature chart;
c. List the different quenching media;
d. Estimate metal heat temperature by color; and,
e. List reasons for stress relieving workpieces.

Module Outline:

I. Discuss the Reasons for Heat Treating
  A. Hardening for utility
  B. Tempering for toughness without brittleness
II. Discuss the Time/Temperature Chart
III. List the Different Quenching Media (In order of *severity* or speed of quenching)
  A. Brine (water and sodium chloride or sodium hydroxide)
  B. Water
  C. Fused (liquid) salts
  D. Molten lead
  E. Soluble oil and water
  F. Oil
  G. Air
IV. Estimate Metal Heat Temperature by Color
  A. Use of the temper color chart for tempering

Temperature (F)	Temperature (C)	Oxide Color	Suggested Uses
425	220	Light Straw	Steel-cutting tools
462	240	Dark Straw	Punches & Dies
490	258	Gold	Shear blades
500	260	Purple	Wood-cutting tools
540	282	Violet	Screwdrivers
580	304	Pale Blue	Springs
620	327	Steel Grey	None

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  - B. *Chicken Wire* markings warn of overheating.
- V. List Reasons for Stress Relieving Workpieces
  - A. Increased machinability
  - B. Increased workability in cold processes
- VI. Special Safety Concerns of Heat Treating
  - A. Protective Gear against. . .
    - 1. Heat
    - 2. Fumes
    - 3. Concussion
  - B. Toxicity of Certain Media
- VII. Special Problems in Heat Treating
  - A. Brittleness
  - B. Distortion
  - C. Discoloration (sometimes unimportant)
  - D. Inadvertent heat treating

MFG-D4-HO
Test Metal Samples for Hardness
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Perform file test to test for metal hardness;
b. Use other tests to identify metals; and,
c. Perform Rockwell hardness tests.

Module Outline:

I. Perform File Test to Test for Metal Hardness
    A. Imprecise method, good for rough estimates only
    B. Requires more experienced machinist
II. Use Other Tests to Identify Metals
    A. High-carbon steels show more spark bursts than do low-carbon steels.
    B. Non-ferrous metals
        1. Aluminum
        2. Magnesium
        3. Brass
        4. Bronze
        5. Nickel
        6. Tin
        7. Others
III. Perform Rockwell Hardness Tests
    A. Ferrous metals
    B. Non-ferrous metals
IV. Perform Brinell Hardness Tests
    A. Ferrous metals
    B. Non-ferrous metals
V. Other Hardness Tests as Specified by the Instructor
    A. Ferrous metals
    B. Non-ferrous metals

MFG-D4-LE
Test Metal Samples for Hardness
Attachment 2: MASTER Laboratory Exercise

I. The instructor should demonstrate the aluminum/magnesium test using the zinc chloride solution.

II. Each student should receive eye or full face protection and three to five samples for evaluation.

III. Each sample should be file-tested.

IV. Each sample should be spark-tested.

V. Each sample should be tested for hardness on the Rockwell tester.

RESULTS OF TESTS

Record your answers on the following charts. Under "Characteristics," write what you saw (spark length, color, etc.) or felt (resistance, heating, etc.) during the test.

FILE TEST

Sample	Characteristics	Preliminary Identification
1		
2		
3		
4		
5		

SPARK TEST

Sample	Characteristics	Preliminary Identification
1		
2		
3		
4		
5		

ROCKWELL HARDNESS TEST

Sample	Rockwell Hardness Number	Preliminary Identification
1		
2		
3		
4		
5		

BRINELL HARDNESS TEST

Sample	Brinell Hardness Number	Preliminary Identification
1		
2		
3		
4		
5		

OTHER HARDNESS TEST

Sample	Hardness Designation	Preliminary Identification
1		
2		
3		
4		
5		

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-D5-HO
Understand Welding Operations
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Perform the basic SMAW process;
b. Perform the basic oxyacetylene cutting and welding process;
c. Perform the basic GTAW (Heliarc) process; and,
d. Perform the basic GMAW (MIG) process.

Module Outline:

DON'T CARRY A BOMB IN YOUR POCKET!

NEVER carry a butane lighter into a welding area. These are mini-Molotov cocktails.

I. Safety Procedures Specific to the Welding Process
  A. Specific safety precautions must be taken to ensure a proper breathing atmosphere in all welding areas.
    1. Weld only in ventilated areas. Welding shielding gases can displace the air needed for breathing. These gases are odorless and colorless, and most are heavier than air.
    2. Weld in a position that will allow your head to be out of the welding plume, but will still give a good view of the welding arc. The welding plume could contain harmful fumes and gases.
    3. Provide enough ventilation wherever welding and cutting are performed. Welding in confined spaces may require special procedures, such as the use of an air-supplied hood or hose mask.
    4. Do not weld on dirty plate or plate contaminated with an unknown material. The fumes and gases which are formed could be hazardous to health.
  B. Electrical shock can be avoided by following specific safety precautions.
    1. Do not touch live electrical parts.
    2. Ground all electrical equipment and the work-piece to prevent accidental electrical shocks.
    3. Use the correct welding cable size for both the ground lead and the welding lead. Sustained overloading will cause cable failure and result in possible electrical shock or fire hazard.

    4. Be sure all electrical connections are tight, clean, and dry. Poor electrical connections can heat up and even melt, causing dangerous arcs and sparks.
    5. Keep dry. Moisture and water can conduct electricity. Fix water leaks immediately.
    6. Keep welding cables and connectors in good condition. Improper or worn electrical connections can cause short circuits and can increase the chance of an electrical shock.
    7. Avoid open-circuit voltage. Open-circuit voltage is much higher than welding voltage.
    8. Shut off electrical power when working on welding equipment.

C. Ultraviolet and infrared rays emitted by the welding arc, as well as the spatter from the welding arc, can injure eyes and burn skin. Specific safety precautions must be followed to ensure adequate protection.
    1. Wear 100% cotton clothing. It will not catch fire easily, it offers good protection from light welding spatter, and it is cooler in the summer and warmer in the winter.
    2. Cover all skin surfaces. Keep shirt sleeves rolled down.
    3. Wear cuffless pants to eliminate spatter traps.
    4. Wear leather boots. Pant legs should cover boot tops.
    5. Wear clean clothing. Oil- and grease-stained clothes will tend to ignite from welding spatter.
    6. For more severe welding conditions, wear protective clothing such as heat resistant jackets, aprons, and leggings.
    7. Wear safety glasses to protect from arc flashes, mechanical injury, or other mishaps.
    8. Wear ear protection, not only where there is noise but where there is a chance that spatter or sparks could get into the ears.
    9. Wear a 100% cotton cap to protect the head from sparks or spatter.
    10. Wear long-gauntlet leather gloves.
    11. Do not touch hot metal with bare hands. Use tongs or pliers and wear leather gloves.
    12. Protect nearby workers from exposure to the welding arc by putting up shields.
    13. Wear a welding helmet with the correct shade of welding lens. Choose the correct lens from a filter recommendations table (See Figure 1).

FILTER RECOMMENDATIONS (adapted from ANSI Safety Standard Z49.1-88) SMAW		
Application	Minimum Shade No.	Suggested Shade*
Less than 60 amps	7	9
60 to 160 amps	8	10
160 to 250 amps	10	12
250 to 500 amps	11	14

* As a general rule, start with a shade that is too dark to see the arc zone. Then go to the next lighter shade until you find one which gives you sufficient view of the arc zone without exerting a strain on your eyes.

Figure 1 Filter Recommendations

D. Specific precautions must be taken to ensure that there is no loss of property due to welding sparks, spatter, and heat.

1. If possible, weld in specially designated areas or enclosures of noncombustible construction.
2. Remove combustibles from the work area by at least 35 feet if possible.
3. Cover combustibles that cannot be removed from the welding area with tight-fitting, flame-resistant material. Items that should be covered include combustible walls, floors, ceilings, and any cracks or other openings that might let a spark pass through it.
4. If welding is to be performed on or adjacent to a metal wall, ceiling, or partition, move combustibles on the other side to a safe location.
5. If combustibles cannot be adequately sealed off or removed, station a fire watcher at that location. The fire watcher must have adequate fire extinguishing capabilities.
6. Do not weld on materials having either a coating or internal structure that is combustible.
7. Place hot scrap and slag in non-combustible containers.
8. Ensure that fire extinguishers are available nearby.

9. Conduct a thorough examination for evidence of a fire before leaving the work area, and continue a fire check for at least 30 minutes after the welding operation has been completed.
10. Follow all company safety procedures regarding welding in hazardous areas.

E. Specific Safety Precautions for Oxyacetylene Equipment

CAUTION: Specific preventive and protective safety measures must be followed when using oxyacetylene equipment:

1. Use goggles or shield with a number five shade.
2. Wear gloves, long sleeve shirts, pants of high cotton or wool content, leather boots, and soft cotton caps.
3. When lighting the torch, direct the torch away from yourself and other personnel.
4. Never leave a lit torch unattended. When leaving your work station, always extinguish your torch.
5. Never use matches or butane lighters for lighting a torch. Only use spark or friction lighters.
6. Never cut on containers that have contained flammable or toxic substances.
7. Either move work away from or protect wooden or other flammable materials which may be close to the work.
8. When cutting, cover concrete floors with sheet metal where sparks and molten metal are being directed.
9. Before beginning to work, locate the nearest fire alarm and the nearest fire extinguisher.
10. Cut in a well-ventilated area. If adequate ventilation is not possible, use a respirator.
11. Keep all petroleum products away from oxyacetylene equipment and operations. The combination of pure oxygen and oil is explosive.

F. Specific Safety Precautions for Acetylene and Oxygen Cylinders

CAUTION: Handle acetylene and oxygen cylinders carefully:

1. Keep acetylene operating pressures at or below 15 psi.
2. Open the acetylene cylinder valve one-half to one full turn when using a portable rig to be sure that the cylinder can be quickly turned off in the event of burn-back or a fire at a leak in the hose or at a connection.
3. Do not open the acetylene torch valve where acetylene could flow into a bucket or other container and cause a fire.
4. Never attempt to connect an acetylene hose to an oxygen torch connection. Damage to the torch or an explosion could result. Acetylene hoses are colored red and acetylene fittings are left-hand threaded and usually notched.
5. Never use oxygen or fuel gas from a cylinder except through an approved pressure-reducing regulator.

6. Do not use pipe-fitting compounds or thread lubricants for making connections.
7. Never use a cylinder that is leaking.
8. Store and transport cylinders in the upright position.
9. Secure all cylinders with chain when storing, transporting, or using, to prevent them from being turned over by accident.
10. Never tamper with fusible plugs or other safety devices on cylinders.
11. To open and close acetylene cylinder valves not provided with hand-wheels, always use the special wrench or key. When cutting, leave the key in place for rapid shutdown in case of fire.
12. Never use any cylinder, full or empty, as a roller or support.
13. Never use oxygen as though it were compressed air.
14. Do not handle oxygen cylinders on the same platform with oil.
15. Never use wire-rope slings or electromagnets for lifting cylinders. Do not lift cylinders by the protective cap alone.
16. Store oxygen cylinders separately from fuel gas cylinders.
17. Always keep empty cylinders separate from full cylinders.
18. Mark all empty cylinders as such after use.
19. Keep all cylinders stored inside buildings at least 20 feet away from combustible materials.
20. Never bring any arc or flame close to or directly into contact with a cylinder.
21. Never exceed the maximum safe withdrawal rate for acetylene cylinders (one seventh of the cylinder's *current* contents per hour). If acetylene is withdrawn from the cylinder at a greater rate, acetone will also be withdrawn from the cylinder, damaging the cutting equipment. If additional flow is needed, then manifold the required number of cylinders together.

G. Specific Safety Precautions for Regulator Burnout (R.B.O.)

CAUTION: Avoid potentially deadly regulator burnout (R.B.O.). Regulator burnout is a spontaneous explosion that happens when a torch is being lit. To minimize the risk of R.B.O., follow these safety precautions:

1. "Crack" the oxygen cylinder valve (open it slightly) before attaching the regulator. Stand to one side or the rear of the cylinder outlet. Open the cylinder valve slightly for an instant and then close it to clean the valve of dust and dirt which may have accumulated during storage. Dirt can damage an oxygen regulator and may cause R.B.O.
2. Use only oxygen regulators to control oxygen supply. A pressure-reducing regulator must be connected to the oxygen cylinder valve. Make certain the regulator is clean, free of grease and oil, and has a clean filter installed in its inlet nipple.

Oil, grease, coal dust, and other combustibles can cause regulator burnouts. Never use an oxygen regulator for other gases.

3. Before opening an oxygen cylinder valve, make sure the oxygen regulator pressure-adjusting screw is released. This is done by rotating the screw counterclockwise until it turns freely. This closes the regulator valve and prevents damage due to a sudden pressure surge.
4. While opening the oxygen cylinder valve, stand to one side of the oxygen regulator. Do not stand in line with the front or the back of the pressure-adjusting screw. Open the cylinder valve as slowly as possible, until the high pressure gauge reaches cylinder pressure. Never open a cylinder valve suddenly. Sudden surges of high pressure can cause R.B.O.

II. Describe the SMAW Process

Shielded Metal Arc Welding is a welding process which joins metals by heating them with an arc between a covered metal electrode and the metals being joined. Shielding is obtained from the decomposition (breakdown) of the electrode covering. Pressure is not used and filler metal is obtained from the electrode. The electric arc flowing across an air gap produces very intense heat and light. An electric arc has been measured at 10,000°F. Considering that steel melts at around 2800°F, the electric arc is indeed a very fast and efficient heat source for melting steel when welding.

III. Describe the Oxyacetylene Cutting and Welding Process

Oxyacetylene cutting requires the use of specific procedures and specific techniques in order to work safely and to produce acceptable cuts. Proper flame adjustments, torch angles, and flame-to-work distances must be maintained in order to produce good cuts. Oxyacetylene cutting can be done from both fixed cutting stations and from portable cutting stations.

The key operations to oxyacetylene cutting are as follows:

1. Prepare to cut.
2. Light the torch.
3. Cut metal with the torch.
4. Extinguish the torch.

HOW TO SELECT THE CORRECT NUMBER OF ACETYLENE CYLINDERS

To determine the number of cylinders required for proper manifold operation, follow the guidelines below:

1. The number of cylinders in the manifold is determined by the volume of gas in cubic feet per hour required. Determine the cubic feet per hour required for the largest tip used and multiply that by the number of torches or stations in operation at the same time. This will give the total volume of each gas required per hour.
2. The manifold should have enough cylinders to provide a minimum of one day's requirements.
3. Maximum acetylene withdrawal for continuous operation is 1/7 (of 14%) of each cylinder capacity per hour. The chart allows for 7.8% excess capacity.

CFH acetylene withdrawal per hour required	Number of 300 cubic foot cylinders per manifold
40	1
80	2
120	3
160	4
200	5
240	6
280	7
320	8
360	9
400	10
440	11
480	12
520	13
560	14
600	15
640	16
680	17
720	18
760	19
800	20

Acetylene Cylinder Manifold Guide

IV. Describe the GTAW (Heliarc) Process
V. Describe the GMAW (MIG) Process
VI. Describe the Band/Flash Welding Machine and Process

MFG-D5-LE
Understand Welding Operations
Attachment 2: MASTER Laboratory Exercise

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1. The instructor will demonstrate each of the following processes:
   a. Basic SMAW process;
   b. Basic oxyacetylene cutting and welding process;
   c. Basic GTAW (Heliarc) process; and,
   d. Basic GMAW (MIG) process.

2. The students will practice each of the following processes:
   a. Basic SMAW process;
   b. Basic oxyacetylene cutting and welding process;
   c. Basic GTAW (Heliarc) process; and,
   d. Basic GMAW (MIG) process.

Rules of Conduct

1. **Absolutely no horseplay or practical joking will be tolerated.**
2. **Do not talk to anyone who is operating a machine.**
3. **Walk only in the designated traffic lanes.**
4. **Dress appropriately; at the absolute minimum, you must have:**
    a. **No loose clothing, including ties;**
    b. **Long hair properly stowed;**
    c. **No jewelry;**
    d. **Hard, closed-toe shoes;**
    e. **Eye protection (safety glasses); and,**
    f. **Ear protection (plugs or headset).**
5. **Follow all institutional safety rules.**

MFG-D6-HO
Evaluate Plastics, Composites and Other Manufacturing Processes
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to:

a. Demonstrate an understand terms related to the plastics industries: (e.g., classification, structure, manufacture, ingredients, available forms, and properties);
b. Identify common methods of processing plastics and composites, and describe in general terms how the processes work;
c. Discuss the powder metallurgy process (e.g., the processes involved in simple die compaction, the methods by which metal powders are produced, the metallurgical principles involved in bonding of powders in the sintering process, the advantages of several advanced powder metal processes, and the reasons for deciding to use powder metallurgy processes for manufacturing a part); and,
d. Discuss other nontraditional machining processes (e.g., electrical discharge machining (EDM), electrochemical machining (ECM), electrolytic grinding (ELG), LASER machining, ultrasonic machining, hydrojet machining, electron beam machining (EBM), and plasma technology) and describe in general terms how each of these processes work, and describe applications of the processes.

Module Outline:

I. Discuss Plastics
    A. Classifications of plastics
        1. Thermoplastics - These are plastics which become soft when exposed to heat and harden when cooled no matter how often the process is repeated. They can be reshaped many times by altering the heating and cooling. Important members of this group are acrylics, cellulosics, nylons, polystyrenes, polyethylenes, fluorocarbons, and vinyls.
        2. Thermosets - These plastics are set or cured into a permanent shape by heat and once set cannot be remelted and returned to their original state. Prominent members of this group of plastics are phenolics, aminos, polyesters, epoxies, and alkyds.
    B. Plastic Structure
        1. In the formation of plastics, many atoms are combined to form molecules. Each atom is joined to the next by connecting links called valence bonds. Their structure is chain-like.

   2. In the thermoplastics, the atoms and molecules are joined end-to-end into a series of long chains, each chain independent of the others. When subjected to heat, this allows slipping of the chains, causing plastic flow.
   3. The structure of thermosets is also chain-like and, before molding, similar to that of thermoplastics. The curing or hardening process (usually during molding) consists of the formation of cross-links between adjacent molecules resulting in a complex, interconnected network. These cross-bonds prevent the slippage of individual chains, thus preventing plastic flow with the addition of heat.

C. How plastics are made
   1. Although plastics are synthetics, they are made from many common natural materials such as wood, air, water, petroleum, natural gas, and salt. These natural materials are broken apart by separating their basic molecules and atoms. They are recombined in different ways with the aid of heat, pressure, and chemical action.
   2. A simplified description of the manufacture of polystyrene illustrates the process. The raw materials used are coal and petroleum or natural gas. Benzene is extracted from the coal, and ethylene gas is obtained from the petroleum or the natural gas. The benzene and ethylene are then linked to form ethyl benzene. The last stage involves processing the ethyl benzene with heat and pressure and then milling and grinding it to form the final result, polystyrene.

D. Ingredients of plastics
   1. Resin - Resin is a binder which serves to bind the plastic together and to impart some of the principal characteristics to the material. The resin determines whether the plastic is thermosetting or thermoplastic.
   2. Filler - Before being processed into finished products, most plastics make use of a filler. Examples of fillers are wood flour and asbestos.
   3. Solvent - A solvent is used to make the resin fluid so that the particles in plastics weld together. This is necessary because some resins are hard and brittle in their natural state.
   4. Plasticizers - Plasticizers are used to lower viscosity at high processing temperatures and to impart plasticity to the final product.
   5. Stabilizers - Stabilizers are often added to prevent degradation by heat, light and aging.
   6. Colorants - Most plastics are not left in their natural color. Over 800 colorants are available to give the plastic products the desired color.

E. Available Forms

1. Molding Compounds - Some plastics are made into various solid forms which are convenient amounts of powder pressed together into larger discs to facilitate weighing and handling. Another similar form is called premix. This is usually a putty form of reinforcing fibers with polyester or epoxy resins.
2. Liquid Casting Resins - Many plastics, both thermoplastics and thermosetting, are available as liquids for casting and reinforcing. This liquid is often a two-part system with one part being a catalyst or curing agent for the other.
3. Solid Structural Shapes - Most plastics are further processed from molding compounds and liquid casting resins into sheets, rods and tubes of many dimensions, cross-sectional shapes, and surface finishes.
4. Coatings - Plastics have replaced many of the natural resins as constituents of finishes. Many quick-drying finishes are plastics.
5. Adhesives - In the field of adhesives, plastic resins have replaced many natural materials and have solved joining problems impossible for previous adhesives.
6. Expanded or Expandable - A number of plastics are available in expanded or expandable form. These are light in weight and appear to be full of bubbles or air spaces. A common rigid foam is made from polystyrene under the trade name of "Styrofoam."
7. Laminates - Laminate is a general term referring to a material made up of sheets or webs of paper, fabric, fibrous glass, or aluminum. This material is first impregnated or coated with a plastic resin and then bonded under heat and pressure to form sheets or panels or various types.
8. Fibers and Filaments - Some plastics are extruded into continuous filaments. As filaments, polystyrene is used as bristles for brooms, and nylon is the popular monofilament line for spinning-type fishing equipment.

F. Properties of plastics

1. Physical Properties - Most plastics are relatively light in weight. Some will float on water. The heaviest plastics are the fluorocarbons which are approximately 2.3 times heavier than water. Plastics are not very hard. The hardest types compare with brass and aluminum. Many plastics have tensile strengths varying from 5,000 to 10,000 psi. Most plastics will elongate several times their length before they will break. Plastics do not commonly expand and contract with the addition or loss of water as does wood. Plastics are particularly vibration absorbent, about ten times more so than steel.
2. Electrical Properties - Nearly all plastics, when dry, are excellent insulators. Some have been developed which retain

their insulating values even after long emersion in water. Some plastics have been developed that will actually carry current. Oriented polyester films are often used as insulators in capacitors because of their high dielectric constant. Polyethylene and polystyrene have very low dissipation factors and cannot be heat sealed electronically; the cellulosics have a high power factor and are readily sealed in this manner. In an insulating material, the dissipation factor is the ratio of the total power loss in the material to the product of the voltage and current in a capacitor in which the material is the insulator.

3. Thermal Properties - Plastics fall in the group of heat insulators; this is, they have very low thermal conductivities. Copper transmit over 2000 times as much heat as most plastics. Plastics exhibit relatively high specific heats. Most plastics are good thermal insulators, especially the foamed plastics. In general plastics are low in heat resistance. Plastics have good resistance to cold. The refrigeration industry makes extensive use of plastics.
4. Chemical Properties - Most plastics are extremely resistant to weak acids. The fluorocarbons are probably the most resistant of all plastic to the effects of acids. Most plastics are very resistant to weak alkalies, but only about half of them resist strong alkalies completely. Exceptional plastics in this respect are the styrenes, polyethylenes, and fluorocarbons. Most plastics are resistant to common vegetable and mineral oils and greases.

II. Discuss Plastic Molding Processes

A. Blow molding - "air is used to force a mass of molten plastic against the sides of a mold shaped in the form of the desired end product."

B. Vacuum forming - a vacuum is drawn on one side of the material and air pressure on the opposite side forces the material against the mold or form

C. Injection molding - "molten plastic is forced into a metal die cavity that has been machined into the shape of the desired end product." When the plastic has solidified (cooled) the die is opened and the part is removed.

D. Reaction injection molding (RIM) - two base resins are mixed together just as they enter the mold. A chemical reaction occurs at low heat and the plastic material of the end product is formed at that instant.

E. Extrusion - plastic material is forced through an extrusion die that forms the end product.

F. Compression molding - the plastic resin is in pellet or dry powder form and is mixed with a binder agent under pressure and then heated to give the part its final form. (This is normally used with thermoset plastics to make many common products to include handles and knobs for kitchen utensils.)

G. Transfer molding - similar to above except that the resin is heated to a liquid state before being forced into the mold.

H. Rotational molding - the mold cavity is spun and centrifugal force causes the resin to flow into the mold.

III. Discuss Composite - The Mechanical Properties of Plastic Can Be Greatly Enhanced by Adding a Reinforcing Agent to the Resin. Plastic Resins May Be Reinforced with Cloth, Paper, Glass Fibers, and Other Fibers Such as Graphite, Thus Forming *Advanced Composite Materials*.

A. Discuss composite molding processes

1. Fiber glassing - alternate layers of glass fibers fabric and resin are coated over a mold or form built in the shape of the finished product. (Examples: spas and boats.)

2. Calendaring or rolling - "plastic is rolled thin to form sheets or film" which is bonded to other materials for protection or other purposes.

3. Plastic materials mixed with paint and sprayed or brushed on products. (Example: polyurethane-based paints.)

4. High-pressure lamination - (Example: plastic laminate bonded over wood base to form a molded top for a kitchen cabinet.) Note: composites differ from reinforced plastics in that the fiber structure is continuous throughout the structure. It is this particular structural design that gives the composite its superior mechanical properties.

B. Discuss the advantages of composites

1. Excellent strength-to-weight ratio
2. Resistance to corrosion
3. Resistance to impact
4. Ability to be formed into complex shapes

C. Discuss composite manufacturing methods

1. Pulltrusion - the fiber portion is pulled or drawn through the liquid resin and then through a heated die that forms the desired shape (Example: structural members and tube.)

2. Filament winding - the fiber is wound back and forth on a cylindrical form. After curing, the form is removed leaving the hollow composite product.

3. Laminating - alternate layers of resin containing the structural fiber are rolled or spread over the surface of the mold.

IV. Discuss the Powder Metallurgy Process - Powder Metallurgy, Commonly Known as P/M, Is Essentially the Compression of Finely Divided Metal Powder into a Briquette of the Desired Shape. The Briquette Is Then Heated to Form a Metallurgical Bond Between the Metal Particles. Over Half the P/M Products Are Used in the *Transportation* Industry.

A. How P/M parts are made. (Basic steps)

1. Compacting (molding) - loose powder (or blend) is placed in a die and pressed into shape (called a green compact). (Usually there is a mixture of different metal powders.) The ejected parts are called *"briquettes."*
2. *Sintering* - heated in the proper atmosphere to cause the powders to bond together.
3. Secondary operations - sizing, machining, grinding, heat treating, deburring, plating, or impregnating with oil.

B. Producing metal powders. (*Iron* is the most used powder.)
  1. Reduction of oxides - iron is heated to mush then crushed.
  2. Electrolysis - deposits on a electrical cathode (very pure).
  3. Atomization - heated metal is sprayed through a nozzle then ground to the desired fineness.
  4. Metal powders range in size from .0001" to .002".

C. Compacting of powders - powders are pressed from both top and bottom in dies that form the powder into the desired shape. Since compaction is from top and bottom, the powders flow in the direction of compaction.
  1. Mechanical presses - rapid rate of production (50,000 parts per hr. at about 30 tons of pressure).
  2. Hydraulic presses - very high pressure (5,000 tons).

D. Sintering - the green compact part is heated to 60 to 80 percent of its melting temperature. *Infiltration* - process in which the pores or voids of a sintered or unsintered compact are filled with a metal or alloy of a lower melting point.

E. Secondary operations:
  1. Sizing
  2. Impregnation
  3. Plating
  4. Other machining or grinding operations

F. Advantages of P/M products (See the textbook)

V. Discuss Other Nontraditional Machining Processes - The Design and Manufacturing Engineer, in the Continuing Search for Improvements in Designs, Both Stimulates Development of Alternate Materials Processing Methods and Takes Advantage of New Processes That Evolve Naturally Throughout Manufacturing Industries. This Chapter Deals with Many of the Newer, Nontraditional Machining Processes.

A. Electrodischarge Machining (EDM) - removes material by an electrical spark erosion process. Metal is removed as the spark pulses and bursts towards the workpiece.
  1. This process takes place in a dielectric (nonconducting) oil bath. This fluid concentrates the spark and also flushes away the spark eroded workpiece material.

    2. EDM electrodes - usually made from metal or carbon (graphite) and shaped by molding, machining. Since the electrode "is also eroded away," usually a roughing and a finishing electrode will be used.
    3. Wire EDM - uses a slender wire as an electrode. Works much like a contour bandsaw.

B. Electrochemical Machining (ECM) - a "reverse metal-plating" process in that chemicals are pumped onto the surface of the workpiece which erode into the surface of the part. This is used for *weight reduction.*

The Process: After cleaning, the metal areas which are *not* to be chemically machined are coated with a "*maskant*" which is resistant to the chemical action.

C. Electrolytic Grinding (ELG) - an electrical conducting, metal grinding wheel forces nonconducting abrasive grains over the surface of the workpiece eroding material.

D. Laser machining - (LASER - Light Amplification by Stimulated Emission of Radiation) - the use of coherent laser light instead of a cutting tool. Used mostly for thin materials.

E. Ultrasonic machining - similar to sand blasting only high frequency sound is used as the motive force to propel abrasive particles against the workpiece.

F. Hydrojet machining - uses an extremely high pressure water jet. Sometimes an abrasive material is added to the water.

G. Electron Beam Machining (EBM) - this process uses a continuous beam of electrons to erode the material. This process must be carried on in a *vacuum* chamber with special shielding to protect personnel from X-ray radiation.

H. Plasma technology - plasma is created by "passing a gas through an electric arc." The gas is ionized by the are and an extremely high temperature is produced. These temperatures can be in excess of 40,000 degrees. This is many times hotter than an electrical arc or a flame.

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

Duties		← Tasks →												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

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MFG-E1-HO
Understand Metrology Terms
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Discuss the use of metrology in manufacturing;
b. Discuss the Inch system of measurement;
c. Discuss the Metric system of measurement;
d. Discuss semi-precision and precision measurement; and,
e. Discuss the following: precision, reliability, discrimination, and accuracy.

Module Outline:

I. Discuss the Use of Metrology in Manufacturing
    A. Discuss the function and reason for measurements in manufacturing
    B. Discuss the changes (metrology related) in manufacturing today
        1. Interchangeable manufacture
        2. World trade
        3. High precision
II. Discuss the Inch System of Measurement
    A. Discuss fractional (scale) dimensions for linear measurement
    B. Discuss decimal dimensions for linear measurement
    C. Convert fractional to decimal
        1. Review mathematical conversion method
        2. Fractional/decimal conversion charts
    D. Practice and demonstration of skills listed above
III. Discuss the Metric System of Measurement
    A. Discuss the units of measure commonly used in the metric system
    B. Convert inch to metric
        1. Review mathematical method (1 inch = 25.4 mm)
        2. Conversion charts
    C. Practice and demonstration of skills listed above
IV. Discuss Semi-Precision and Precision Measurement
    A. Discuss the difference between semi-precision and precision measurement
        1. Semi-precision measurements are 1/64" (.5mm) or greater
        2. Precision measurements are less than 1/64" (.5mm)
    B. Discuss the five categories of precision measurement
        1. Outside measurement
        2. Inside measurement
        3. Depth measurement

        4. Thread measurement
        5. Height measurement

V. Discuss the Following Measurement Terms: Accuracy, Precision, Reliability, and Discrimination
    A. *Accuracy* - whether or not something is made according to standard. (The standard for manufacturing is the blueprint.)
    B. *Precision* - the degree of exactness required for an application or design requirement
    C. *Reliability* - the ability to consistently obtain the desired result
    D. *Discrimination* - the degree that a measuring instrument divides its basic unit of length

MFG-E2-HO
Select Measurement Tools
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify basic semi-precision measuring tools;
b. Identify precision measuring tools;
c. Justify use of particular measurement tools based on tool characteristics;
d. Identify error possibilities in measurement tool selection; and,
e. Demonstrate proper care of precision measuring tools.

Module Outline:

I. Describe and Discuss the Following Semi-Precision Measuring Tools
  A. Steel rules
  B. Calipers
  C. Squares
II. Describe and Discuss the Following Precision Measuring Tools
  A. Micrometers (outside, inside and depth)
  B. Verniers (calipers and height gage)
  C. Gages (small hole, telescope, fixed, and dial bore)
III. Justify Use of Particular Measurement Tools Based on Tool Characteristics
  A. What tolerance is required by the print?
  B. What physical characteristics of the part influence tool selection?
  C. What is the discrimination of the tool?
  D. How much time is available for part measurement/inspection?
  E. Will the tool be used by itself or in conjunction with some other tool?
  F. What is the most reliable tool for this application?
IV. Identify Error Possibilities in Measurement Tool Selection
  A. Part not being produced to specifications
  B. Too much time spent trying to measure correctly by not having the right tool
V. Demonstrate Proper Care of Precision Measuring Tools
  A. Storage
  B. Handling
  C. Cleaning

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-E3-HO
Measure With Hand Held Instruments
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Measure with steel rules (metric and inch);
b. Measure with micrometers;
c. Measure with comparison measuring instruments (e.g., calipers, telescope gages);
d. Measure with direct measuring instruments (e.g., vernier, dial and digital instruments); and,
e. Measure with fixed gages (go and no-go gages).

Module Outline:

I. Discuss the Importance of Learning and Practicing Proper Measurement Techniques
  A. Show the video "Measuring Tools"
  B. Give each student a copy of the handout "Proper Measuring Techniques"
II. Discuss and Demonstrate Proper Measurement Techniques Using the Steel Rule
III. Discuss and Demonstrate the Use of Micrometer Type Measuring Instruments
  A. Outside micrometers
  B. Inside micrometers
  C. Depth micrometers
  D. Practice and demonstration of skills listed above
IV. Discuss and Demonstrate the Use of Transfer Type Measuring Instruments
  A. Spring calipers (inside and outside)
  B. Telescope gages
  C. Small hole gages
  D. Practice and demonstration of skills listed above
V. Discuss and Demonstrate the Use of Direct Measuring Instruments
  A. Vernier calipers
  B. Dial calipers
  C. Digital calipers
  D. Practice and demonstration of skills listed above
VI. Discuss the Purpose of Fixed Gages and Demonstrate Their Use
  A. Cylindrical plug and ring gages
  B. Taper plug and ring gages
  C. Snap gages

    - D. Thread plug gages
    - E. Practice and demonstration of skills listed above
- VII. Complete Practical Exercise (MFG-E3-LE1) and (MFG-E3-LE2) On All the Above Material

Name:________________ Date:____________________

MFG-E3-LE1
Measure With Hand Held Instruments
Attachment 2: MASTER Laboratory Exercise No. 1

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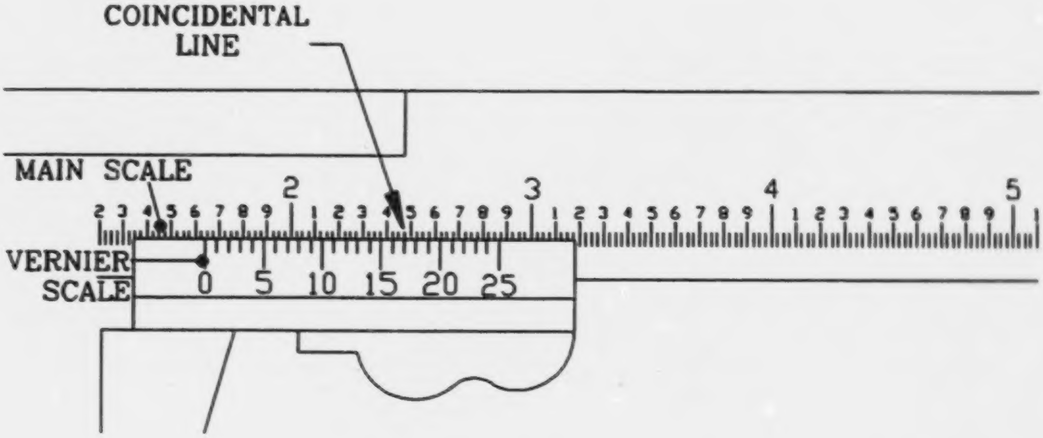
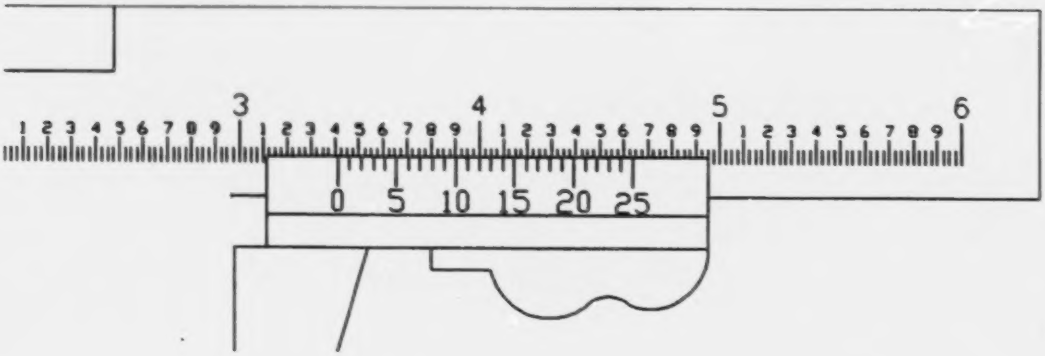
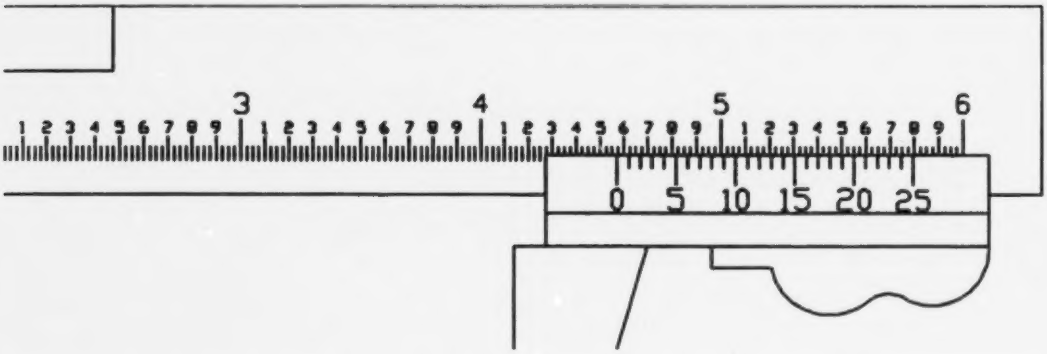
1. What is the reading on the vernier caliper below?
   - a. .642
   - b. 1.642
   - c. 1.645
   - d. 1.64


COINCIDENTAL LINE
MAIN SCALE
VERNIER SCALE
2
3
4
5
2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9
0 5 10 15 20 25

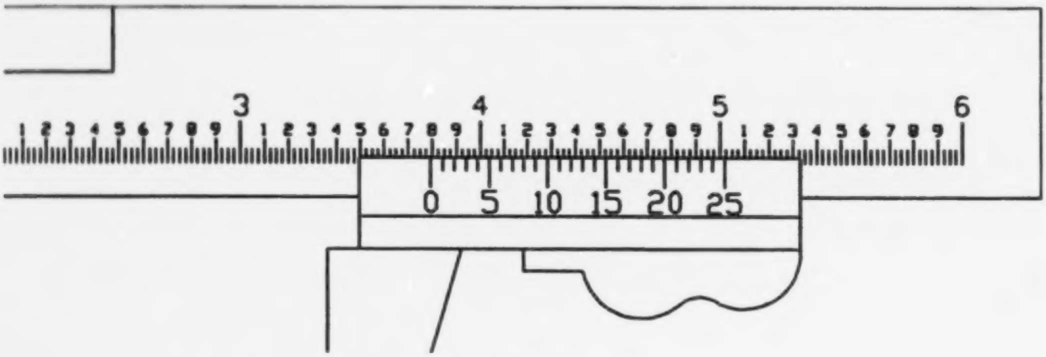
2. What is the reading on the vernier caliper below?
   - a. .415
   - b. 3.125
   - c. 3.405
   - d. 3.412


3
4
5
6
1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9
0 5 10 15 20 25

3. What is the reading on the vernier caliper below?
   a. 4.575
   b. 4.250
   c. 4.570
   d. 4.275


3
4
5
6
1 2 3 4 5 6 7 8 9
0 5 10 15 20 25

4. What is the reading on this vernier caliper?
   a. 3.785
   b. 3.800
   c. 3.473
   d. 3.793


3
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1 2 3 4 5 6 7 8 9
0 5 10 15 20 25

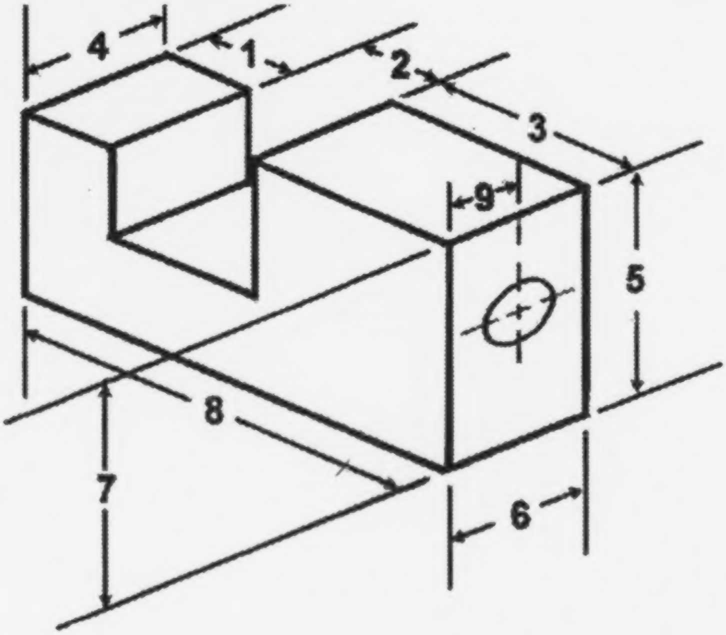
Name____________________________ Date________________

MFG-E3-LE2

Measure With Hand Held Instruments

Attachment 3: MASTER Laboratory Exercise No. 2

Using the measuring instruments provided for you and the measuring specimens, measure for the following dimensions and record your answers in the space provided. Be sure to provide metric and inch answers for each dimension. Turn this sheet in to your instructor for evaluation.



Specimen Number _______

Dimension	metric	inch	Dimension	metric	inch
1.	_____	_____	7.	_____	_____
2.	_____	_____	8.	_____	_____
3.	_____	_____	9.	_____	_____
4.	_____	_____	10.	_____	_____
5.	_____	_____	11.	_____	_____
6.	_____	_____			

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-E4-HO
Eliminate Measurement Variables
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Discuss factors affecting accurate measurement (dirt, temperature, improper measuring tool calibration);
- b. Explain calibration requirements of various precision instruments;
- c. Illustrate measurement differences when taken with calibrated and non-calibrated instruments; and,
- d. Calibrate a micrometer type measuring tool.

Module Outline:

- I. Discuss Factors Affecting Accurate Measurement
  - A. Tool selection
  - B. Cleanliness
  - C. Temperature
  - D. Calibration
  - E. "Feel"
- II. Explain Calibration Requirements of Various Precision Instruments
  - A. Individual responsibility vs. company responsibility
  - B. Calibration standards
- III. Illustrate Measurement Differences When Taken With Calibrated and Non-Calibrated Instruments
- IV. Calibrate a Micrometer Type Measuring Tool
  - A. 5 steps adjusting an outside micrometer which needs adjustment
    1. Clean the measuring faces of the micrometer
    2. Close the measuring faces carefully against the standard by turning the ratchet stop or friction thimble
    3. Insert the C-spanner into the hole or slot provided in the sleeve
    4. Carefully turn the sleeve until the index line on the sleeve coincides with the zero line on the thimble
    5. Recheck the accuracy of the micrometer by opening and then closing the micrometer faces by turning the ratchet stop or friction thimble
  - B. Student practice of the above procedure

MFG-E4-LE
Eliminate Measurement Variables
Attachment 2: MASTER Laboratory Exercise

The student will perform the following:

1. Calibrate a micrometer by:
    a. Adjusting micrometer;
    b. Cleaning the measuring faces of the micrometer;
    c. Closing the measuring faces carefully against the standard by turning the ratchet stop or friction thimble;
    d. Inserting the C-spanner into the hole or slot provided in the sleeve;
    e. Carefully turning the sleeve until the index line on the sleeve coincides with the zero line on the thimble; and,
    f. Rechecking the accuracy of the micrometer by opening and then closing the micrometer faces by turning the ratchet stop or friction thimble.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
   a. No loose clothing, including ties;
   b. Long hair properly stowed;
   c. No jewelry;
   d. Hard, closed-toe shoes;
   e. Eye protection (safety glasses); and,
   f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-E5-HO
Measure/Inspect Using Surface Plate and Accessories
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Describe care of surface plate;
b. Use surface plate accessories correctly (sine bar, gage blocks, etc.);
c. Check for part squareness;
d. Check part dimensions for accuracy; and,
e. Align workpieces using height gage and dial indicators.

Module Outline:

I. Describe Types of Surface Plate and Surface Tables
    A. Cast iron and semi-steel surface plates
    B. Granite surface plate
II. Discuss the Different Surface Plate Accessories and Their Use
    A. Sine bar
    B. Gage blocks
    C. Vernier height gage
    D. Precision height gage
    E. Dial test indicator
    F. Squares
    G. Angle plate and clamps
    H. 1,2,3 blocks
III. Demonstrate Checking For Part Squareness
IV. Demonstrate Checking Part Dimensions For Accuracy
V. Demonstrate Aligning Workpieces Using Height Gage and Dial Indicators

MFG-E5-LE
Measure/Inspect Using Surface Plate and Accessories
Attachment 2: MASTER Laboratory Exercise

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1. Instructor will provide sample mechanical parts for students to:
   a. Demonstrate checking for part squareness;
   b. Demonstrate checking part dimensions for accuracy; and,
   c. Demonstrate aligning workpieces using height gage and dial indicators.

2. Students will practice:
   a. Checking for part squareness;
   b. Checking part dimensions for accuracy; and,
   c. Aligning workpieces using height gage and dial indicators.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-E6-HO
Inspect Using Stationary Equipment
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Set up and use an Optical Comparator; and,
b. Set up and use a Coordinate Measuring Machine (CMM).

Module Outline:

I. Define the Term "Comparison Measurement"
  A. Describe the following comparison instruments:
    1. Dial indicator
    2. Mechanical comparator
    3. Optical comparator
    4. Mechanical-optical comparator
    5. Air gages
    6. Electronic comparator
  B. Demonstrate the setup and operation of the optical comparator
  C. Allow students to practice setup and operation of the optical comparator

II. Discuss the Advantages of Measuring with the Coordinate Measuring Machine (CMM)
  A. Demonstrate the setup and operation of the CMM
  B. Allow students to practice setup and operation of the CMM

MFG-E6-LE
Inspect Using Stationary Equipment
Attachment 2: MASTER Laboratory Exercise

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1. The instructor will:
    a. Demonstrate the setup and operation of the optical comparator; and,
    b. Demonstrate the setup and operation of the Coordinate Measuring Machine (CMM).

2. The students will:
    a. Practice the setup and operation of the optical comparator; and,
    b. Practice the setup and operation of the Coordinate Measuring Machine (CMM).

MFG-E6-LA
Inspect Using Stationary Equipment
Attachment 3: MASTER Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	← Tasks →												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MFG P&E
[illegible]

MFG-F1-HO
Prepare and Plan for Machining Operations
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Read and interpret blueprints;
b. Understand machinability and chip formation;
c. Use the *Machinery's Handbook* as a reference for machine applications;
d. Describe the tools and toolholders will be needed for machining operations;
e. Calculate speeds, feeds, and depth of cut for various machine operations;
f. Use carbides and other tool materials;
g. Assemble work holding (fixturing) components; and,
h. Perform basic semi-precision and precision layout as necessary.

Module Outline:

I. Plan for Machining Operation
   A. Read and interpret blueprints
   B. Understand machinability and chip formation
   C. Use the *Machinery's Handbook* as a reference for machine applications
   D. Answer the following questions
      1. What operations are necessary to produce the part? (qualify, rough, finish, grind, face, turn, thread, groove, etc.)
      2. What sequence of tools will be used?
      3. How will the part be fixtured? Fasteners should not interfere with machine moves. (Clamps, vise, chucks, collets, etc.)
      4. How many set-ups will be required?
      5. What is the accuracy required for machining dimensions?

II. Prepare for Machining Operations
   A. What type of tools and toolholders will be needed for roughing, finishing, etc.? Use carbides and other tool materials when available. Verify tool availability.
   B. Calculate speeds, feeds, and depth of cut for various machine operations
   C. Assemble work holding (fixturing) components
   D. Perform basic semi-precision and precision layout as necessary
   E. Load the part into the workholding (fixturing) device

Rules of Conduct

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3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-F2-HO
Use Hand Tools
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

- **a. Select and use hand tools;**
- **b. Select and use hand files;**
- **c. Correctly identify and use hand taps and dies as required;**
- **d. Select and use hand reamers;**
- **e. Use arbor and shop presses; and,**
- **f. Perform off-hand grinding operations.**

Module Outline:

- I. Select and Use Hand Tools
  - A. Bench vise
  - B. Clamps
  - C. Pliers
  - D. Hammers
  - E. Wrenches
  - F. Screwdrivers
  - G. Chisels and punches
  - H. Hacksaws
- II. Select and Use Hand Files
  - A. Types of files
    - 1. Mill file
    - 2. Long angle (lathe) file
    - 3. Bastard files
  - B. Shapes of files
    - 1. Pillar files
    - 2. Square files
    - 3. Warding files
    - 4. Knife files
    - 5. Three-square files
    - 6. Half-found files
    - 7. Round files
  - C. Specialty files
    - 1. Swiss pattern files
    - 2. Die sinker's rifflers
    - 3. Curved tooth files
    - 4. Thread files
    - 5. Rotary files and burrs

    - 6. Scrapers
  - D. Care and use of files
    - 1. Proper care of files
    - 2. Proper use of files
      - a. Cross filing
      - b. Draw filing
  - E. Student filing practice
- III. Correctly Identify and Use Hand Taps and Dies as Required
  - A. Identification of taps
    - 1. Identifying marks on inch taps (example: ½-13-UNC)
      - a. Nominal size = ½"
      - b. Threads per inch = 13
      - c. Standardized thread series = Unified National Coarse
    - 2. Identifying marks on metric taps (example: M4 X 0.7)
      - a. M = metric thread
      - b. Nominal diameter of the thread = 4mm
      - c. Pitch of the thread = 0.7mm
    - 3. Standard taps
      - a. Taper (starting) taps
      - b. Plug taps
      - c. Taper taps
    - 4. Special taps
      - a. Pipe taps
      - b. Pulley taps
      - c. Acme thread taps
  - B. Care and use of taps
    - 1. Proper care of hand taps
    - 2. Determining tap drill size
      - a. Tap drill size chart
      - b. Tap drill size formula for inch taps
        Tap Drill Size = Major Diameter of the Tap minus 1 divided by the number of threads per inch
      - c. Tap drill size formula for metric taps
        Tap Drill Size = major diameter (mm) minus the pitch (mm)
    - 3. Demonstrate proper use of hand taps
    - 4. Broken tap removal
      - a. Tap extractor
      - b. Acid
      - c. Electrical discharge
  - C. Identification and use of threading dies
    - 1. Solid die - for chasing or recutting damaged threads
    - 2. Adjustable split die - for cutting threads over or under the standard depth of thread

        3. Adjustable screw plate die - most efficient type of adjustable die for cutting external threads
    D. Student tap and die practice
IV. Select and Use Hand Reamers
    A. Types of hand reamers
        1. Straight fluted reamers
        2. Spiral fluted reamers
        3. Expansion reamers
        4. Adjustable hand reamers
        5. Taper reamers
    B. Care and Use of Hand Reamers
        1. Proper care of hand reamers
        2. Proper use of hand reamers
    C. Student hand reaming practice
V. Perform Finishing Processes
    A. Broaching
    B. Lapping
    C. Polishing
VI. Use Arbor and Shop Presses
    A. To install bushings/bearings
    B. To press shafts in and out of gears and sprockets
    C. To seat mandrels
    D. To broach keyways
    E. To bend and straighten
VII. Perform Off-Hand Grinding Operations
    A. Setting up the grinder (demonstration)
        1. Grinding wheel selection
        2. Grinding wheel "ring test"
        3. Mounting the grinding wheel
        4. Tool rest adjustment
        5. Dressing the grinding wheel
    B. Perform off-hand grinding exercises (demonstration)
        1. Sharpen a flat blade screwdriver
        2. Sharpen a cold chisel
        3. Grind/Sharpen a high speed cutting bit
    C. Student practice of grinding exercises

MFG-F2-LE
Use Hand Tools
Attachment 2: MASTER Laboratory Exercise

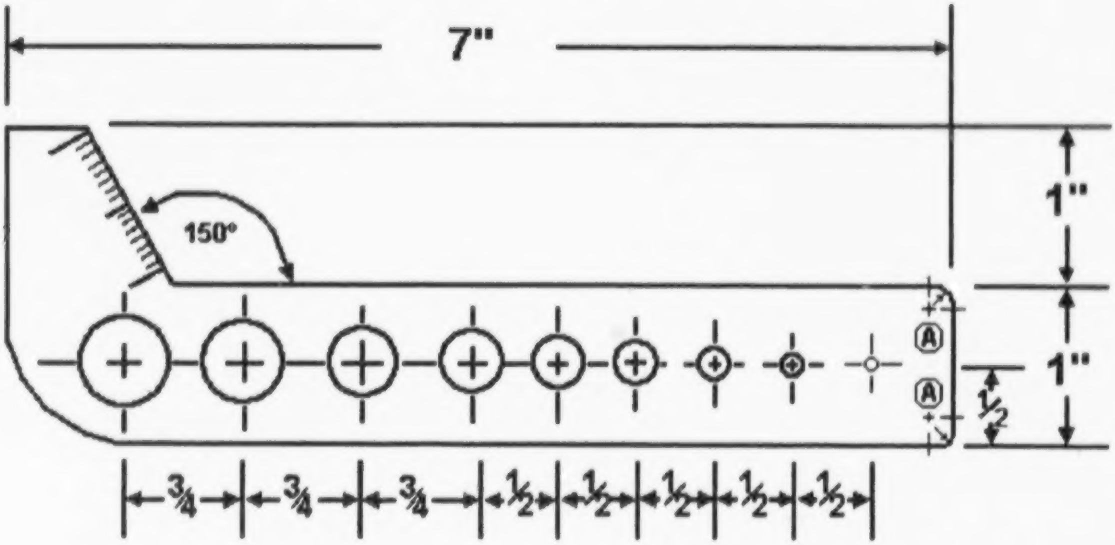
For this exercise, you will make a drill/hole gage.

Necessary Equipment:

- 1/8" x 2" x 8" steel bar (cold finish)
- 3/4" radius gage
- File, Double cut
- File, single cut
- Hacksaw
- Layout tools
- Steel Rule for straight edge
- Vise

I. Layout
  A. Scribe the cutting lines.
  B. Scribe the hole centers.
  C. Center punch the hole centers.
II. Cutting
  A. Leave a 1/32" lip on each cut. This lip will be filed off to finish the tool.
  B. Make sure that the workpiece is firmly in the vise and that the clearance is sufficient to allow cutting.
  B. Cut the 30° angle. Make certain that you do not cut into the body of your tool.
  C. Cut the interior edge. Make sure that you do not cut into the lip rule of your tool.
III. Filing
  A. Straight surfaces
    1. Using a single cut file, draw file all straight edges.
    2. Check the smoothness with the steel rule by holding the steel rule along one edge and looking toward a light.
    3. Continue filing the edge until almost no light is visible between the rule and the gage.
  B. 3/4" radius
    1. Clamp the workpiece securely in the vise.
    2. Using the double cut file, file off the corner, leaving a 1/32" lip for finishing.
    3. Using the single cut file, round the corner by filing forward and downward.
    4. Frequently check the finish with the 3/4" radius gage.
IV. Scribing the lip gage

A. The 30° edge should be marked at 1/16" intervals.
B. Ensure that all lines are parallel.
C. Scribe them into the edge by the method recommended by your instructor.



All Holes Bored Through
Hole Sites:
Left-to-Right

9/16"	1/4"
1/2"	3/16"
7/16"	1/8"
3/8"	1/16"
5/16"	

Ⓐ 1/4" radius round

MFG-F2-LA
Use Hand Tools
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-F3-HO
Operate Power Saws
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Use reciprocating and horizontal band cutoff machines;
b. Operate abrasive and cold saws; and,
c. Setup and use the vertical band saw.

Module Outline:

I. Cutoff Type Metal Saws
  A. Four types of cutoff saws
    1. Power hacksaw - reciprocating type which cuts only on the forward stroke. It is not generally considered to be one of the most efficient cutoff machines in the machine shop.
    2. Horizontal bandsaw - uses a flexible, continuous blade which cuts continuously. They are available in a wide variety of types and sizes and are popular because of their high production and versatility.
    3. Abrasive cutoff saw - cuts metal with a thin abrasive blade which revolves at a high speed. One of it's strengths is that it can easily cut hardened metal.
    4. Friction saw - uses a saw band (usually without teeth) which is run at a very high speed (10,000 to 25,000 sfm) and burns or melts it way through metal. Ideal for cutting thin sections of structural and honeycombed parts of machine or stainless steel.
  B. Types of saw blades
    1. Material - high-speed tungsten and high-speed molybdenum steel is used for saw blades. Power hacksaws have blades which are hardened throughout while flexible blades have only the saw teeth hardened.
    2. Pitch - pitch is the number of teeth per inch. When cutting thick materials choose a saw blade with a course pitch, such as 4-6 to allow for proper chip clearance and maximum bite. When cutting thin materials choose a saw blade with a fine pitch, such as 12-14. 10 pitch is considered to be a good general purpose blade. (*Rule:* Always use a blade which will allow at least 2 teeth to be in contact with the work at all times to avoid tooth breakage.)
  C. Blade removal and installation
    1. Always turn the electrical power off

2. Use a brush to clean the areas (guides) through which the blade must pass
3. Carefully release any blade tensioning device and remove the blade
4. Select the correct blade for the cutting job at hand
5. Install the blade with the teeth facing in the proper cutting direction
6. Tighten the blade tensioning device checking that the blade is properly aligned and tensioned
7. Quickly start and stop the saw to verify proper operation
8. For saws which have adjustable speeds, set the proper cutting speed for the metal to be cut

D. Operation
1. Check vise mounting for tightness and squareness to the cutting blade
2. Place material in the vise (support long pieces with a floor stand)
3. Lower the saw blade until it is close to the work
4. Adjust any blade guides until they just clear the sides of the material to be cut
5. Measure the part to be cut, allowing 1/16" or more for saw run-out
6. Tighten the vise, check length measurement and turn the saw on

E. Sawing hints
1. Never attempt to mount, measure, or remove work unless the saw is stopped
2. Guard long material at both ends to prevent anyone from coming in contact with it
3. Use cutting fluid when possible to help prolong the life of the saw blade
4. When several pieces of the same length are to be cut, set the stop gage to the desired length
5. If the blade dulls or breaks, re-start the cut in a new place

F. Student practice
1. Students should select proper pitch blade for a cutting application
2. Students should practice removal/installation of a saw blade
3. Students should use the saw to cut a piece of metal to length
4. Students should operate abrasive and cold saws if available

II. The Vertical Contour Bandsaw

A. Description of the contour bandsaw parts and accessories
1. Base
2. Column
3. Head

- B. Bandsaw Applications
  - 1. Notching
  - 2. Slotting
  - 3. Splitting
  - 4. Radius cutting
  - 5. Angular cutting
  - 6. Three-dimensional shaping
- C. Blade Variables/Types (the text has excellent illustrations for each of these)
  - 1. Tooth forms -
    - a. Precision or regular
    - b. Claw or hook tooth
    - c. Buttress or skip tooth
  - 2. Pitch - the number of teeth per inch (see above discussion at I,B,2)
  - 3. Set - amount of side to side offset of the teeth for clearance
    - a. Wave
    - b. Straight
    - c. Raker
  - 4. Width - the distance from the tip of the teeth to the back of the blade
    - a. For making straight cuts, select a wide blade
    - b. For cutting small radii, select a narrow blade
    - c. For general cutting, select the widest blade which can cut the smallest radius on the workpiece
  - 5. Gage - the thickness of the saw blade
- D. Bandsaw operation
  - 1. Instructor demonstration of the following
    - a. Blade removal/assembly
      - 1. Unfolding/folding saw blades
      - 2. Measuring and cutting stock saw blade material
      - 3. Welding a saw blade using the band welder
    - b. Cutting speed adjustment
    - c. Saw guide adjustments
    - d. Careful operation of the bandsaw
  - 2. Student practice of the following steps
    - a. Blade removal/assembly
      - 1. Unfolding/folding saw blades
      - 2. Measuring and cutting stock saw blade material
      - 3. Welding a saw blade using the band welder
    - b. Cutting speed adjustment
    - c. Saw guide adjustments
    - d. Careful operation of the bandsaw

III. Cleanup and Review of Main Lesson Points

MFG-F3-LE1
Operate Power Saws
Attachment 2: MASTER Laboratory Exercise No. 1

Laboratory Exercise No. 1:

1. Instructor will demonstrate how to setup and operate a band saw to a designated tolerance without endangering personnel or equipment by:
    - A. Selecting proper blade;
    - B. Installing and properly adjusting the blade;
    - C. Adjusting the blade guides and guard;
    - D. Adjusting the coolant flow if or as appropriate;
    - E. Adjusting feed control (if applicable);
    - F. Properly securing the work and making a cut to specified tolerances; and,
    - G. Shutting down the machine and cleaning up work area.

2. Student will demonstrate how to setup and operate a band saw to a designated tolerance without endangering personnel or equipment by:
    - A. Selecting proper blade;
    - B. Installing and properly adjusting the blade;
    - C. Adjusting the blade guides and guard;
    - D. Adjusting the coolant flow if or as appropriate;
    - E. Adjusting feed control (if applicable);
    - F. Properly securing the work and making a cut to specified tolerances; and,
    - G. Shutting down the machine and cleaning up work area.

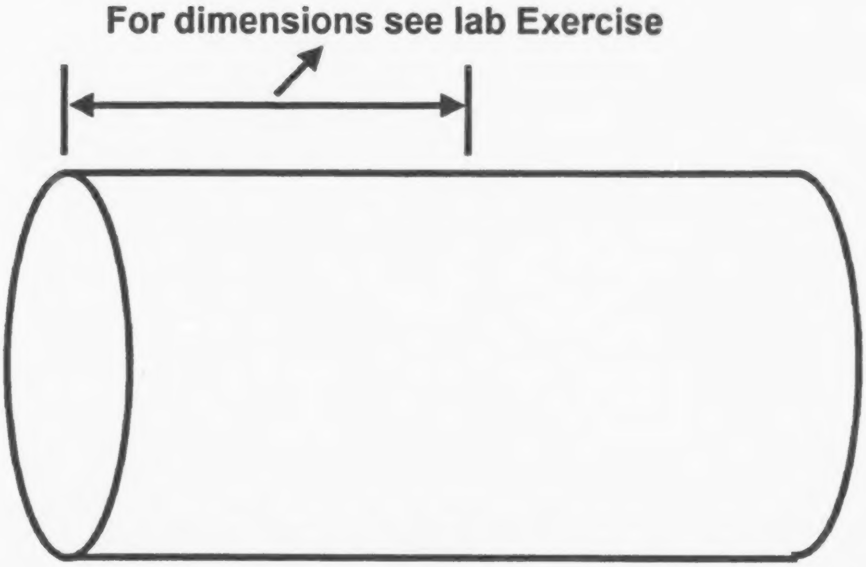
3. Instructor will grade student's performance.

Laboratory Exercise No. 2:

Using each of the saws discussed in the module, the student will cut five workpieces, in different metals or grades of steel. The required accuracy is +/-1/16".

The following five lengths should be cut by each student:

1. 4"
2. 2.5"
3. 40 mm
4. 5 1/8"
5. 50 mm



MFG-F3-LA
Operate Power Saws
Attachment 4: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-F4-HO
Operate Drill Presses
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Describe the different types of drill presses found in the machine shop;
- b. Select and use the standard drilling machine accessories;
- c. Select and use standard drilling tools;
- d. Sharpen a drill bit using a bench or pedestal grinder; and,
- e. Layout, setup and perform these drilling operations: drilling, tapping, countersinking, counterboring, reaming.

Module Outline:

- I. Describe the Different Types of Drill Presses Found in the Machine Shop
  - A. Sensitive drill press
  - B. Upright drill press
  - C. Radial drill press
  - D. CNC drilling machines
- II. Select and Use the Standard Drilling Machine Accessories
  - A. Tool-holding devices
    - 1. Drill chucks
    - 2. Drill sockets, sleeves and drifts
  - B. Work-holding devices
    - 1. Drill vise
    - 2. V-blocks
    - 3. Angle plate
    - 4. Clamps and straps
- III. Select and Use Standard Drilling Tools
  - A. Twist drills
    - 1. Shank
    - 2. Body
    - 3. Points
    - 4. Sizes
      - a. Fractional size drills
      - b. Number size drills
      - c. Letter size drills
      - d. Metric drills
    - 5. Special types of drills
      - a. Straight-fluted
      - b. Spade drills
      - c. Deep hole drills

        - d. Core drills
      - 6. Cutting fluids
        - a. Drilling
        - b. Tapping
    - B. Sharpen a drill bit using a bench or pedestal grinder
      - 1. Review grinder safety
      - 2. Discuss the following drill point characteristics
        - a. Chisel edge
        - b. Lip clearance
        - c. Lip length
        - d. Web thinning
      - 3. Demonstrate this for the students
      - 4. Student practice
- IV. Layout, Setup and Perform These Drilling Operations:
  - A. Drilling
    - 1. Speed (rpm) - discuss the formula.....CS X 4 ÷ diam. = RPM
    - 2. Feed (inch per revolution) - roughing and finishing
  - B. Countersinking
  - C. Counterboring
  - D. Reaming
    - 1. Discuss reaming allowance
    - 2. Speed is normally twice that used for drilling
    - 3. Feed is normally ½ that used for drilling
  - E. Tapping
    - 1. Discuss tap drill size
    - 2. Discuss special taps for machine tapping

MFG-F4-LE1
Operate Drill Presses
Attachment 2: MASTER Laboratory Exercise No. 1

Laboratory Exercise No. 1:

Each student will be assigned two workpieces, made of either two different metals or two greatly different grades of steel.

1. **For the first piece, the student will drill, ream, *counterbore*, and tap the following holes:**
   - A. **3/16"**
   - B. **1/2"**
   - C. **5/8"**
   - D. **4mm**
   - E. **12mm**

2. **For the second piece, the student will drill, ream, *countersink*, and tap the following holes:**
   - A. **3/16"**
   - B. **1/2"**
   - C. **5/8"**
   - D. **4mm**
   - E. **12mm**

MFG-F4-LE2
Operate Drill Presses
Attachment 3: **MASTER** Laboratory Exercise No. 2

Laboratory Exercise No. 2:

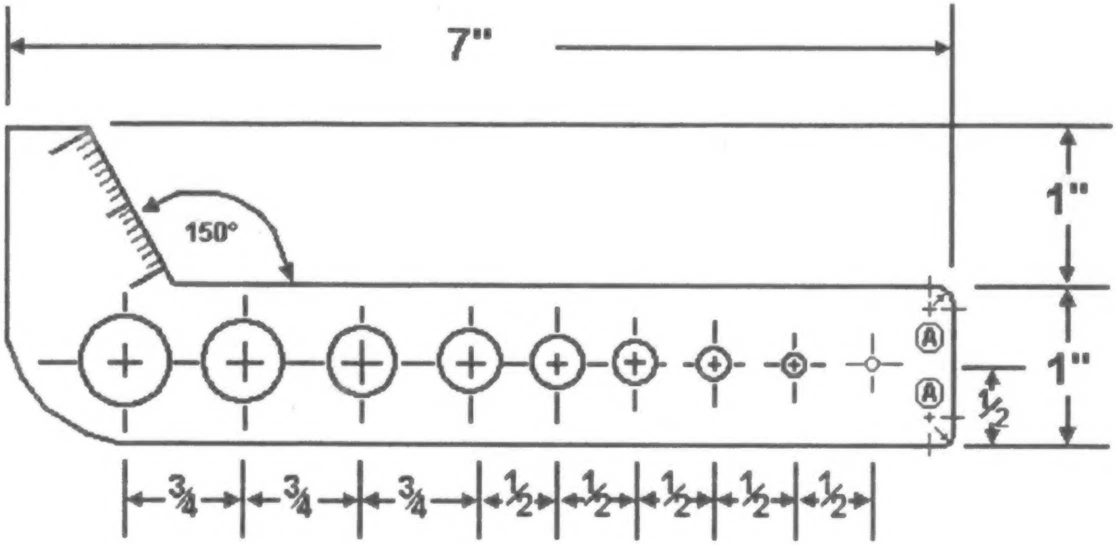
You will now complete your Drill/Hole Gage.

Necessary Equipment:
- #2 Center Drill
- Countersinks of appropriate sizes
- Drill Bits: 9/16", 1/2", 7/16", 3/8", 5/16", 1/4", 3/16", 1/8", 1/16"
- Set of Parallels
- Vise

I. Test the drill bits which you will use. Sharpen them as necessary.
II. Set up the gage and the parallels in the vise so that the 3/4" bit will clear through the gage.
III. With the machine OFF, emplace the center drill. The drill should be centered for the 3/4" hole.
IV. *Without moving the workpiece,* tighten the vise.
V. Drilling
    A. Set the machine to the correct speed for the drill size you are using.
    B. Spot drill all the holes *except* the 1/16" hole. (Spot drilling this hole may cause it to be over size in the finished tool).
    C. Change to the 1/16" bit and drill the hole.
    D. Change to the 1/8" bit and drill that hole. Using the 1/8" bit, pilot drill all larger holes.
    E. Drill the other holes.
    F. Be sure to check the machine speed for each drill size. Adjust the machine speed as necessary.
VI. Countersink each side of each hole. A minimal chamfer is all that is required.

All Holes Bored Through
Hole Sites:
Left-to-Right
9/16"
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
1/8"
1/16"

Ⓐ 1/4" radius round


7"
150°
1"
1"
½
Ⓐ
Ⓐ
¾
¾
¾
½
½
½
½
½

Rules of Conduct

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3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
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    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-F5-HO
Operate Vertical Milling Machines
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Demonstrate the use of all controls on the vertical milling machine;
b. Align the vertical milling machine head;
c. Select, align, and use workholding devices;
d. Select milling tool holders;
e. Select milling cutters;
f. Perform all standard vertical milling operations;
g. Bore a hole using the offset boring head;
h. Machine angles using sine bar and gage blocks;
i Machine keyways; and,
j. Setup and machine dovetails.

Module Outline:

I. Identify Parts and Use All Controls on the Vertical Milling Machine
  A. Base
  B. Column
  C. Knee
  D. Saddle
  E. Table
  F. Ram
  G. Toolhead
  H. Motor
  I. Turret Clamps
  J. Quill, Quill Jack, and Spindle
  K. Controls
    1. Forward/Reverse Motor Switch
    2. Spindle Brake
    3. Power Feed Change Lever
    4. Quill Feed Handwheel
    5. Feed Control Lever
    6. Quill Feed Hand Lever
    7. Feed Reverse Knob
    8. High/Low Speed Change Lever
    9. Variable Speed Control Wheel
    10. Table Reverse Crank
    11. Vertical Traverse Crank
    12. Cross Traverse Crank

        13. Table Power Feed
    L. Locks and Gib Adjusting Screws

II. Setup Milling Machine
    A. Square the Toolhead to Table and Saddle Axes
    B. Select, Align, and Use Workholding Devices
        1. Direct Table Mounting
        2. Mill Vises
        3. Work Edge and Hole Centerline Locating
    C. Select Milling Tool Holders
        1. Solid Collet
        2. Split Collet
        3. Quick-Change Systems
        4. Arbor
    D. Select Milling Cutters
        1. High-Speed Steel Helical End Mills
        2. HSS Straight-Flute End Mills
        3. Carbide EMs
        4. Roughing and Tapering EMs
        5. Geometry-Forming EMs
        6. Dovetail EMs
        7. T-Slot EMs
        8. Woodruff Key EMs
        9. Shell End Mills
        10. Flycutters

VI. Perform All Standard Vertical Milling Operations
    A. Basic Operations and Terms
        1. Climb Milling vs Conventional Milling
        2. Factors Affecting Cutting Performance
        3. Cutting Fluids
            a. Purpose and Use
            b. Selection
            c. Safety
    D. Milling Cavities
    E. Angle Milling
    F. Drilling

VII. Bore a Hole Using the Offset Boring Head
    A. Identify Parts of Boring Head
    B. Workpiece Setup
    C. Tool Selection
    D. Use the Offset Boring Head

VIII. Machine Angles Using Sine Bar and Gage Blocks
    A. Identify Parts
        1. Sine Bar
        2. Sine Plate
        3. Use and Care of Gage Blocks

IX. Machine Keyways
X. Setup and Machine Dovetails and T-Slots

MFG-F5-LE
Operate Vertical Milling Machines
Attachment 2: MASTER Laboratory Exercise

I. The student should align the vertical milling machine head.

II. The student should mill the following forms:
   A. A keyseat in a shaft;
   B. A set of short (no more than 18") dovetail joints;
   C. A cavity in a block; and,
   D. A T-slot in a block 6" long; the T-slot must be parallel to the long side of the block.

III. Evaluation criteria:
   A. The chosen key must fit properly in the keyseat;
   B. The dovetailed workpieces must mate properly;
   C. The cavity in the block must be within the tolerances established by the instructor; and,
   D. The T-slot must accept and freely pass the selected commercial T-nut.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-F6-HO
Operate Horizontal Milling Machines
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Discuss the difference in plain and universal horizontal milling machines;
b. Discuss the types of spindles, arbors and adaptors used on the horizontal milling machine;
c. List several common work holding methods;
d. Use plain milling cutters;
e. Use side milling cutters; and,
f. Use face milling cutters.

Module Outline:

I. Discuss the Difference in Plain and Universal Horizontal Milling Machines
  A. Determine Machine Size
  B. Identify Parts & Controls
    1. Base and Column
    2. Knee
    3. Saddle
    4. Table
    5. Spindle
    6. Overarm and Arbor Support
    7. Controls
      a. Manual movement controls
      b. Feed rate selector and feed engage
      c. Rapid traverse
      d. Spindle controls
      e. Locks
    8. Swivel housing on saddle of Universal Milling Machine
II. Discuss the Types of Spindles, Arbors, and Adaptors Used on the Horizontal Milling Machine
  A. Mill Spindle Tapers
  B. Arbors
    1. Style A
    2. Style B
    3. Style C
    4. Spacing Collars
    5. Bearing Collars
    6. Support Bearings

- C. Adapters
- D. Collets
- E. Quick-Change Systems

III. List Several Common Work Holding Methods
- A. Direct Table Mounts
  1. Clamp supports
  2. Screw jacks
- B. Mill Vises
- C. Miscellaneous Holders
  1. Rotary table
  2. Dividing head
  3. V-Blocks
  4. Specially made milling fixtures

IV. Use Plain Milling Cutters
- A. Roughing
- B. Squaring
- C. Milling Endpieces

V. Use Side Milling Cutters
- A. Setup
- B. Positioning the Cutter
- C. Making the Cut
  1. Keyseats
  2. Straddle and Gang Milling
- D. Helical Side Milling Cutters
  1. Uses
  2. Handedness

VI. Use Face Milling Cutters
- A. Composition and Inserts
- B. Uses
- C. Lead Angles and Rake Angles
- D. Wiper Flats

MFG-F6-LE
Operate Horizontal Milling Machines
Attachment 2: MASTER Laboratory Exercise

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1. The instructor will demonstrate:
    a. How to use plain milling cutters;
    b. How to use side milling cutters;
    c. How to use face milling cutters;
    d. How to recognize and utilize various spindles, arbors, and adaptors; and,
    e. How to set up workpieces appropriately.

2. Students will:
    a. Use plain milling cutters;
    b. Use side milling cutters;
    c. Use face milling cutters;
    d. Recognize and utilize various spindles, arbors, and adaptors; and,
    e. Set up workpieces appropriately.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-F7-HO
Operate Metal Cutting Lathes
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Identify major component parts of an engine lathe;
b. Properly set up and use lathe accessories required for basic lathe operation;
c. Determine correct speed and feed for a given metal;
d. Identify safety concerns relative to lathe operation;
e. Demonstrate set up and use of lathe centers;
f. Identify and use different types of lathe cutting tools;
g. Face, cut and turn stock to a specified tolerance;
h. Demonstrate method of drilling, boring and reaming a hole to obtain specified tolerance; and,
i Demonstrate setup and correct procedures to machine sixty-degree internal and external threads.

Module Outline:

I. Discuss the Importance of the Lathe to the Machinist. Provide Classroom Handouts and Laboratory Worksheets to the Students.
II. Identify and Discuss Component Parts of the Engine Lathe
III. Discuss Lathe Safety
IV. Identify, Set Up, and Demonstrate Use of Lathe Accessories
    A. Cutting Fluids
    B. Follower and Steady Rest
    C. Compound Rest
    D. Mandrel
V. Discuss and Demonstrate How to Select the Correct Speed and Feed for Various Metals
    A. Steel
    B. Aluminum
    C. Brass
VI. Discuss and Demonstrate the Use of Lathe Centers
    A. Mounting
    B. Removing
    C. Aligning
VII. Discuss and Demonstrate Use of Cutting Tools
    A. Grinding a high speed toolbit
    B. Re-conditioning point of toolbits
    C. Types of cutting tools

VIII. Discuss and Demonstrate Turning Between Centers
    A. Why face out?
    B. Center drill
    C. Tailstock center
    D. The steady rest
    E. Using chucks

IX. Discuss and Demonstrate Methods of Drilling, Boring, and Reaming Using the Lathe

X. Discuss Threads, Threading, and Thread Applications

XI. Student Practice

MFG-F7-LE
Operate Metal Cutting Lathes
Attachment 2: MASTER Laboratory Exercise

I. The instructor will discuss and review the working drawings.

II. Students will practice safe work habits at all times.

III. Students will review the work prints at their work stations. (Be sure you understand *all aspects* of the working drawings before beginning the exercise.)

IV. Specific Procedures for This Exercise
  A. General Shop Rules
    1. Immediately put absorbent on all oil spills.
    2. Thoroughly clean the machine and the area around it when you are finished working at that station.
    3. Return all assigned tools to their proper places.
  B. General Lathe Rules
    1. Never attempt to stop a turning chuck.
    2. Never try to measure moving parts. Wait until they stop.
    3. The chuck should always turn *toward* you when it is in the FORWARD position.
    4. The tool steel should not stick out more than one-half inch from the toolholder.

V. Fabrication of the Ball-Peen Hammer—Handle Form
  A. Cut off at least 9 5/8 inches of 1 inch diameter CRS (cutting speed 100); wipe it clean and deburr it on the pedestal grinder using the coarse wheel.
  B. Check the following before starting the lathe.
    1. The spindle should be free.
    2. The carriage should be free.
    3. The cross feed should be free.
    4. The chuck wrench **must** be removed from the chuck.
  C. Face the stock to a length of 9 ½ inches.
  D. Center drill each end.
  E. Put the chuck on 2 inches of the stock and support the workpiece with the tailstock and the live center.
  F. Mark 6 inches from the end of the workpiece with the turning tool.
  G. Turn this 6 inches down to 0.800 inch.
    1. Touch the rotating workpiece with the tool and set the crossfeed dial to zero (0).

        2. Take four cuts of 0.050 at a feed of 0.004.
        3. On the fourth cut, stop the feed after 3/8 inch and check for the proper diameter. Adjust as necessary.
    H. Mark 5/8 inch from the end of the workpiece.
    I. Turn this 5/8 inch down to 0.550.
    J. File all edges using the file handle in the left hand.
    K. File a straight flat along the turned surface in line with the #1 chuck jaw.
    L. Unchuck the workpiece. *Remove the chuck wrench.*
    M. Remove the workpiece and place 2 inches of the turned end into the chuck, placing the file flat under the #1 chuck jaw. *Remove the chuck wrench.*
    N. Adjust the tailstock pressure so that the live center turns with the workpiece.
    O. Mark 4 5/8 inches from the end and turn to 0.700 OD ± 0.005.
    P. Mark 4 3/16 inches from the end and turn to 0.600 OD ± 0.005.
    Q. Mark 3 3/8 inches from the end and turn to 0.425 OD ± 0.005.
    R. Set the lathe to the proper feed and speed for finishing and finish the three ODs from O, P, & Q to the print dimensions.
    S. Break all sharp edges with a file.
    T. Reverse the work. Chuck on the 0.375 OD. *Remove the chuck wrench.* Protect the finished ODs with an appropriate buffer.
    U. Finish turning the handle to the print dimensions.

VI. Fabrication of the Ball-Peen Hammer—Threads and the Head
    A. Cut off at least 4 1/8 inches of 1 inch diameter 4140, painted red (cutting speed 60). Clean and deburr as before.
    B. Face one end.
    C. Mark 5/8 inch from the end and turn to 0.500 + 0.000 -0.010.
    D. File a flat for the #1 chuck jaw, reverse the work and repeat B and C for the other end of the workpiece.
    E. Get the parting tool for the respective machine.
        1. Check the parting tool for sharpness.
        2. Mount the parting tool in the tool post.
        3. Make sure that the parting tool is square to the workpiece and on center.
        4. Feed slowly, using both hands, at 100 RPM.
    F. Cut a neck for the threads to run on at each end of the head and on one end of the handle.
        1. Touch the parting tool to the workpiece and zero the cross slide.
        2. Feed in the double depth of the thread plus 0.010.
    G. Thread both ends of the head to ½-20-NF. Test the threads with a test nut. *Do not proceed to H without instructor approval.*
    H. Thread one end of the handle to ½-20-NF.

I. Either of two common methods of threading may be used. Check with the instructor before proceeding.
    1. Die and Pad
        a. Fix the handle on the large end.
        b. Using the die and the flat crotch pad, thread the small end of the handle to 3/8-24-NF.
    2. Threading Tool—thread to 3/8-24-NF.

J. Chuck onto the practice threads of the head and support the workpiece with the tailstock and live center.

K. Center drill the end of the head.

L. Mark 1 7/8 inches from the shoulder and turn to 0.875 ± 0.003. Make sure that the top tolerance is used to allow for filing and polishing.

M. Mark the #1 jaw, reverse the workpiece and center drill the other end.

N. From the 0.875 OD, turn the workpiece down to 0.750 ± 0.003.

O. Using the threading tool, mark the workpiece
    1. 13/16 inch *in from* the 0.875 OD.
    2. 3/8 inch in from the first mark.
    3. 5/8 inch in from the second mark.
    4. 3/8 inch in from the third mark.

P. Under cut the 3/8 inch spaces to 9/16 inch OD ± 1/64. Use a round nose tool, set the RPM to 100, and feed by hand. Make the last cut slowly to leave the cut smooth.

Q. Turn off the practice threads. Protect the finish in the chuck with an appropriate buffer.

R. Crown face the head end and free-hand form the ball peen.

S. Check all dimensions against the drawing for accuracy.

VII. Fabrication of the Ball-Peen Hammer — Knurling

A. Chuck the handle at the 0.550 diameter (with proper buffers) and support the 0.500 diameter end with a well-lubricated dead center.

B. Carefully mark where the knurl will be made.

C. Set a medium knurling tool square to the workpiece and on center.

D. Set the lathe to the proper feed and speed.

E. Knurl the handle, using plenty of lubricants. Be sure that the pattern is correct *before* knurling the whole handle.

F. Knurl the 1/4 inch cap screw. If a correct pattern is not obtained, knurl the entire handle grip and turn off the poorly-executed end.

VIII. Fabrication of the Ball-Peen Hammer — Completing the Handle

A. Chuck on the knurl (buffer correctly).

B. *While maintaining the tolerances,* file and polish each diameter of the handle separately.

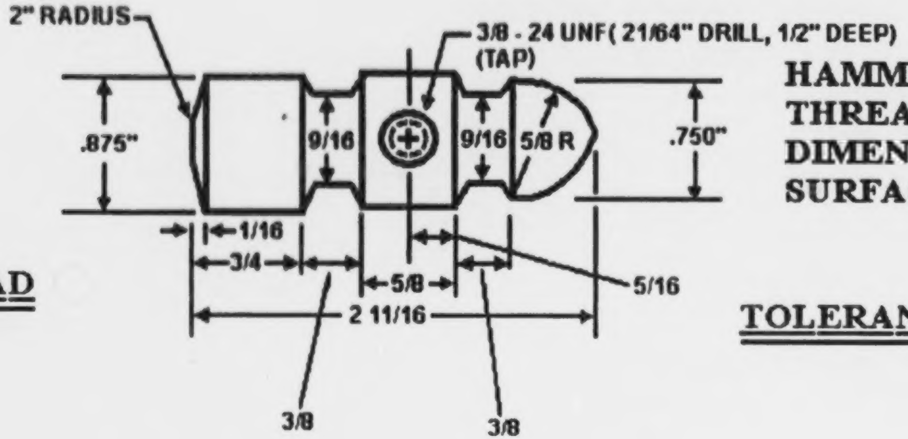
C. Clean the lathe especially well after polishing.

D. Move to the work bench. Place the handle in a vise (buffer the knurl) and saw off the end for the screw with a hacksaw.
E. Face the handle to length and drill and tap the storage hole as required.
F. Clean out the hole and install the screw. (A paper gasket may help prevent over-tightening.)
G. Face the screw to length and break the sharp edge. The handle is now complete.

IX. Fabrication of the Ball-Peen Hammer — Completing the Head
A. Lay out, center punch, and drill the head to the proper depth. Use the drill jig designed for this operation.
B. Tap the bore using a plug and bottom tap. Be sure the taps are started straight.
C. Polish the hammer head and clean the work area.
D. Heat the face of the hammer and the ball peen to cherry red; quench them in oil. Re-polish the head.
E. Heat the face of the hammer and the ball peen to straw color; quench them in oil. Re-polish the head.

X. Turn in the hammer and blueprints to the instructor for evaluation. You will know how well you have done by whether the hammer parts all actually fit together well and whether they are within tolerances.

XI. Once you have obtained the instructor's approval, you are ready to begin construction of the gravity-fed center punch. For that exercise, you will not be given linear instructions. You must use your own judgement on how and when to do what, following the blueprints. Remember to stay within tolerances, to keep your work area clean, and keep your chuck key in your hand or in your tool kit *at all times and in all circumstances*. Good Luck!


2" RADIUS
3/8 - 24 UNF (21/64" DRILL, 1/2" DEEP)
(TAP)
.875"
9/16
9/16
5/8 R
.750"
1/16
3/4
5/8
5/16
2 11/16
3/8
3/8

HEAD

HAMMER GRADE: ____________

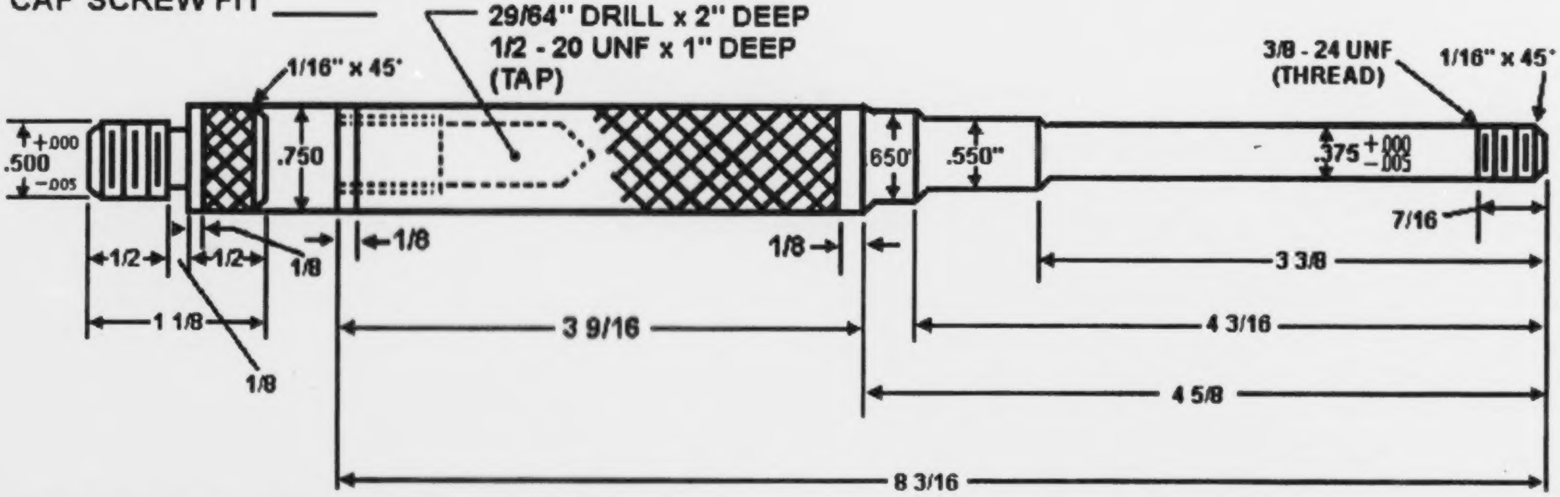
THREAD SQUARENESS: ____________

DIMENSIONS MISSED: ____________

SURFACE FINISH: ____________

TOLERANCES: FRACTIONS ± OR 1/64"
DECIMALS ± OR .005"

CAP SCREW FIT ______

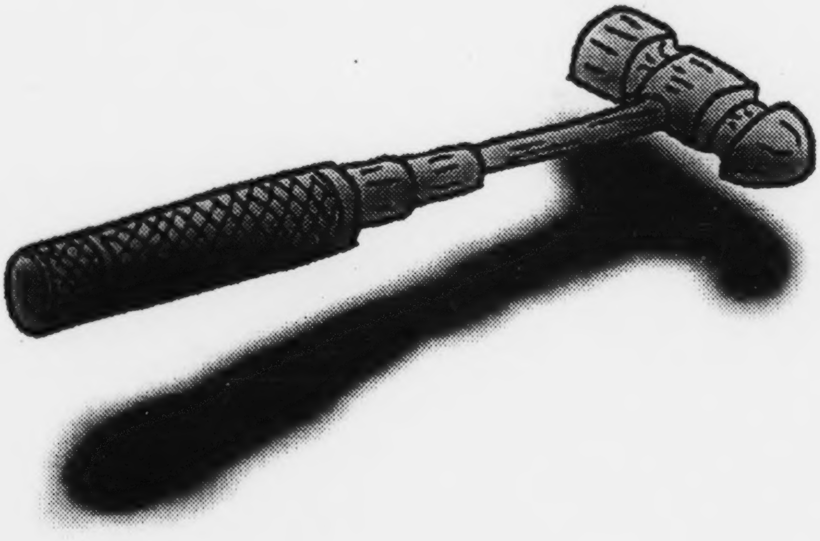

29/64" DRILL x 2" DEEP
1/2 - 20 UNF x 1" DEEP
(TAP)
3/8 - 24 UNF
(THREAD)
1/16" x 45°
1/16" x 45°
.500 +.000 −.005
.750
.650"
.550"
.375 +.000 −.005
1/2
1/2
1/8
1/8
1/8
1/8
1 1/8
1/8
7/16
3 3/8
3 9/16
4 3/16
4 5/8
8 3/16

MATERIAL

HEAD 4140 - HANDLE - C.R.S. 12 L 14

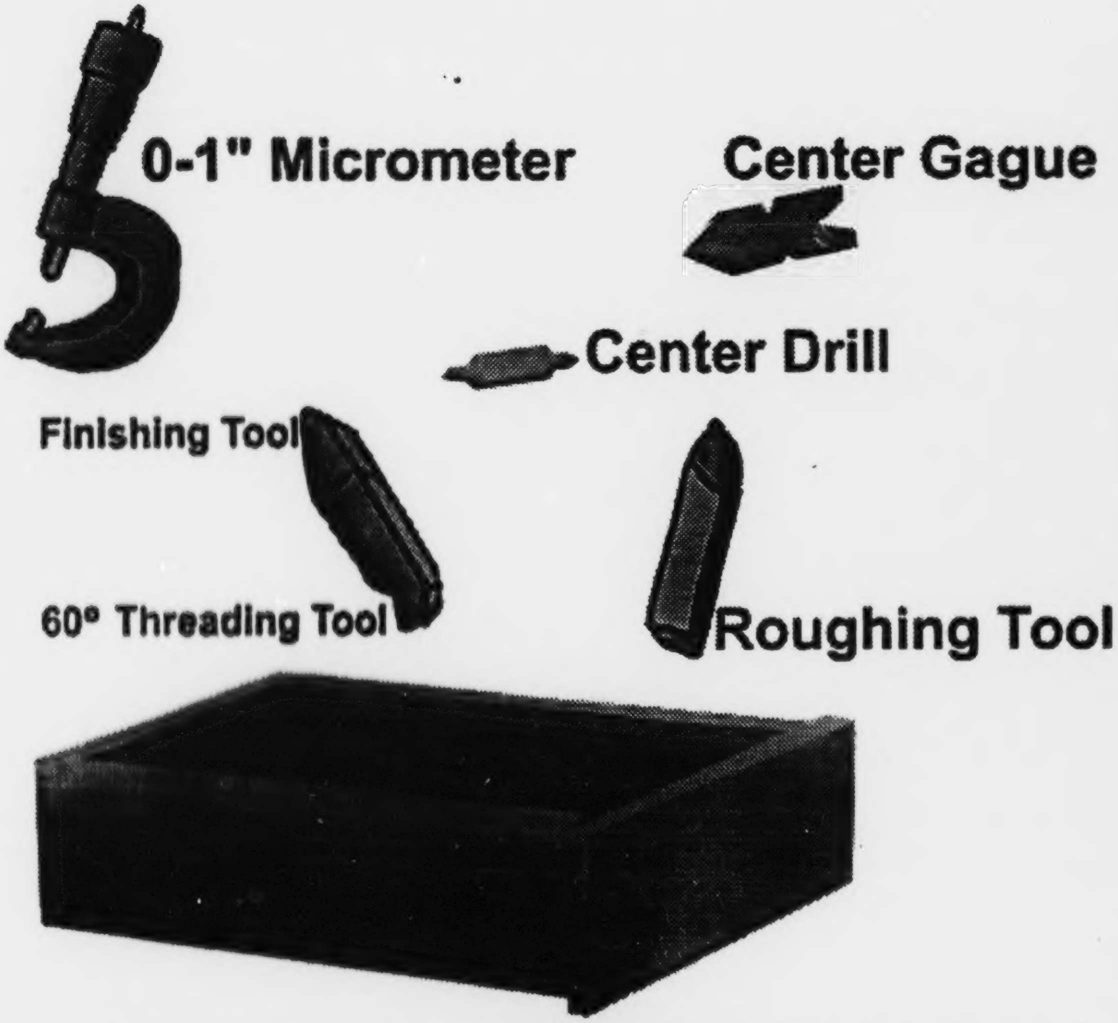
HANDLE

BALL PEEN HAMMER



Objectives:

1. Become accquainted with work done in a machine shop.
2. Practice Engine Lathe Operation.
3. Observe the need for careful measuring.
4. See first hand the need for shop safety.



0-1" Micrometer

Center Gague

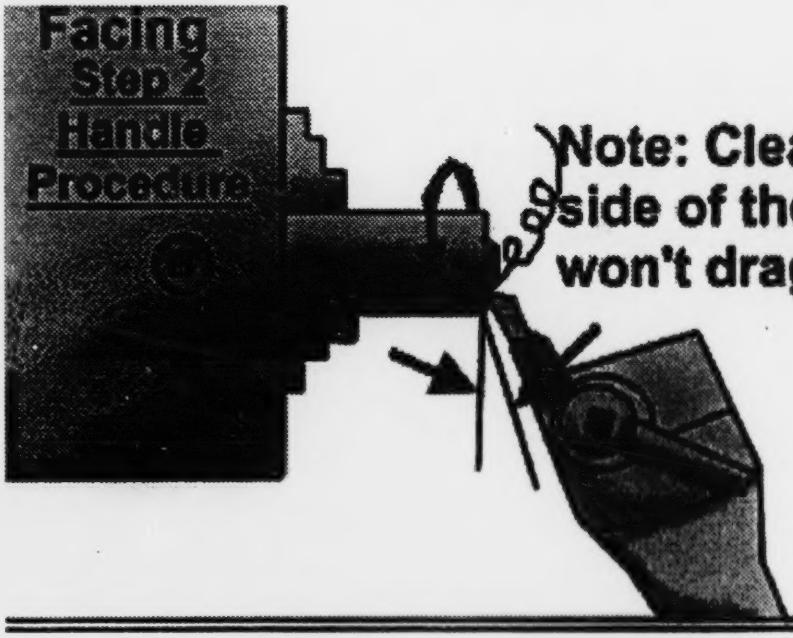
Center Drill

Finishing Tool

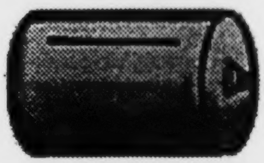
60° Threading Tool

Roughing Tool

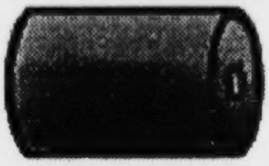
These tools should be in your box.


Facing
Step 2
Handle
Procedure

Note: Clearance so side of the tool won't drag on work.

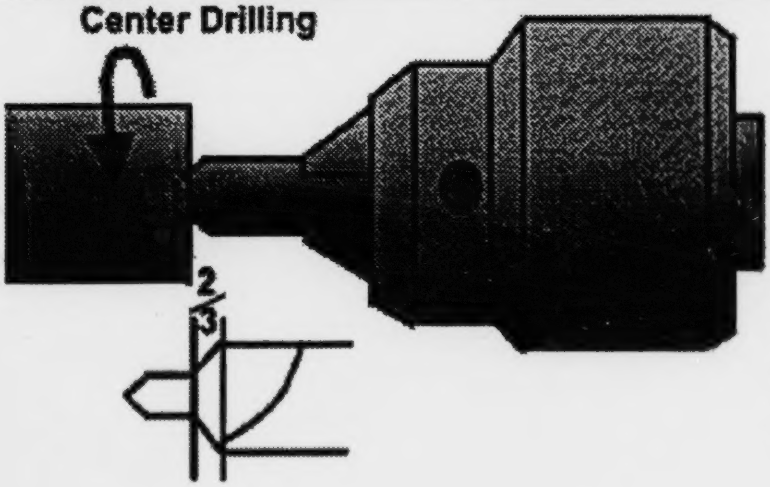


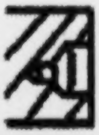
Point, Tool too Low.



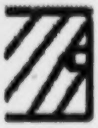
Rough, Tool too High.

Center Drilling

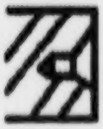




Too Deep

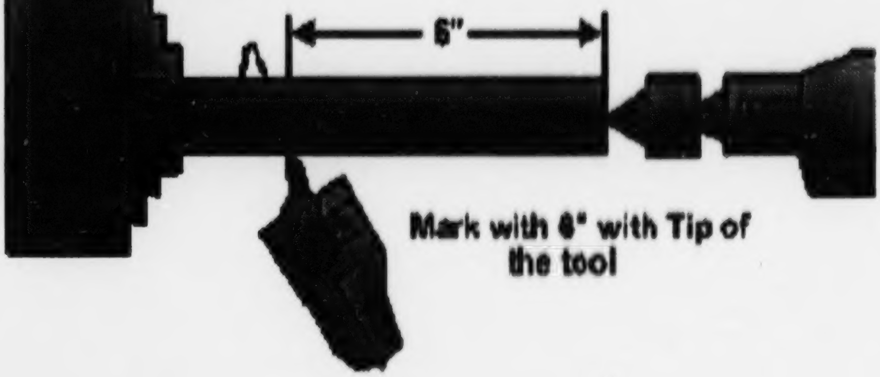


Too Shallow

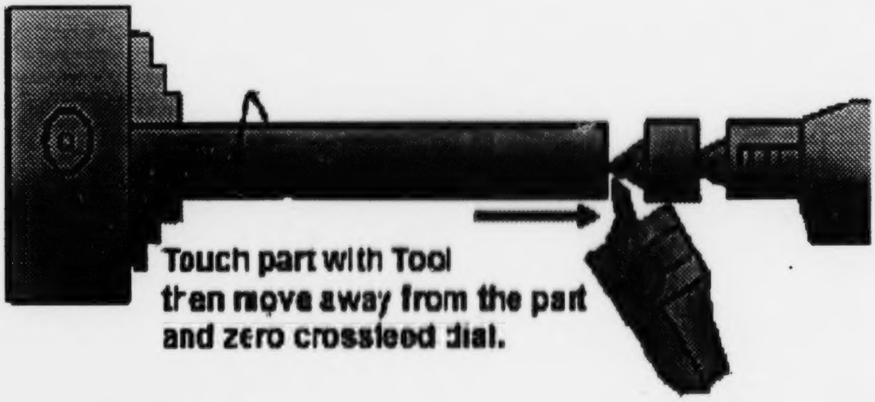


Correct

Step 4



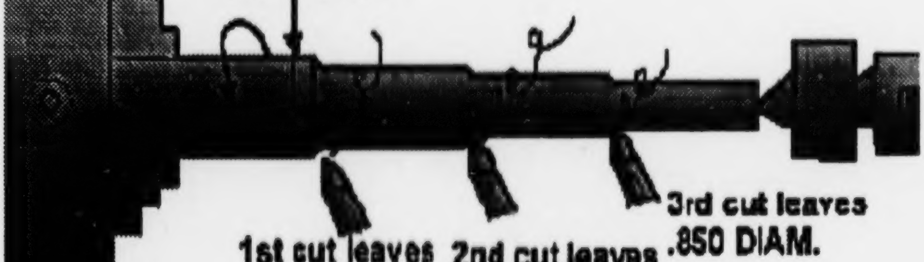
Mark with 6" with Tip of the tool



Touch part with Tool
then move away from the part
and zero crossfeed dial.

STEP 5

Stop each cut
at 6" mark

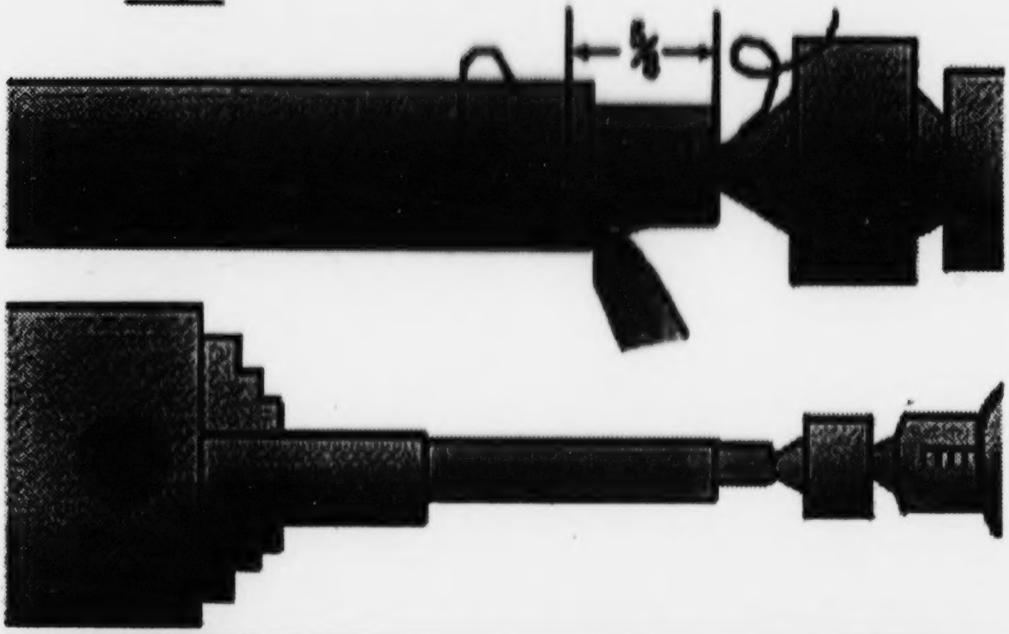


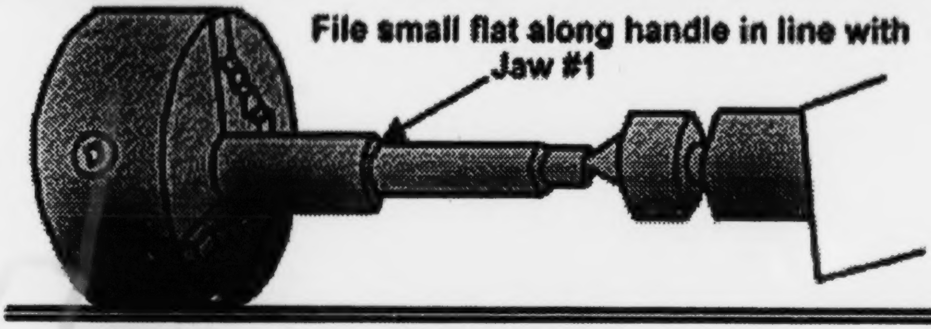
1st cut leaves
.950 DIAM.

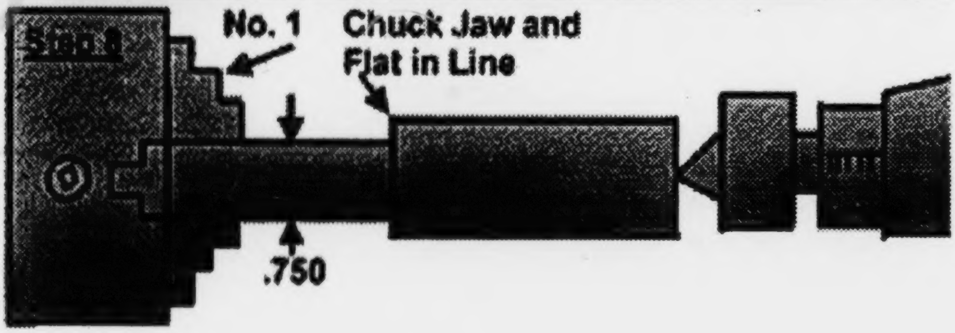
2nd cut leaves
.900 DIAM.

3rd cut leaves
.850 DIAM.

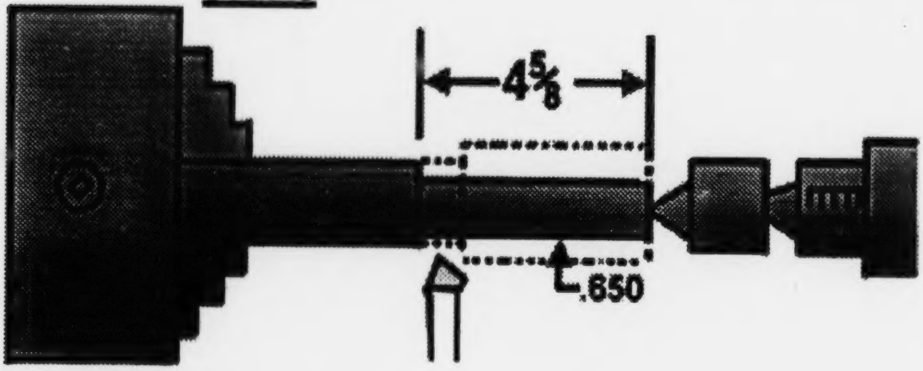
Step 6


5/8

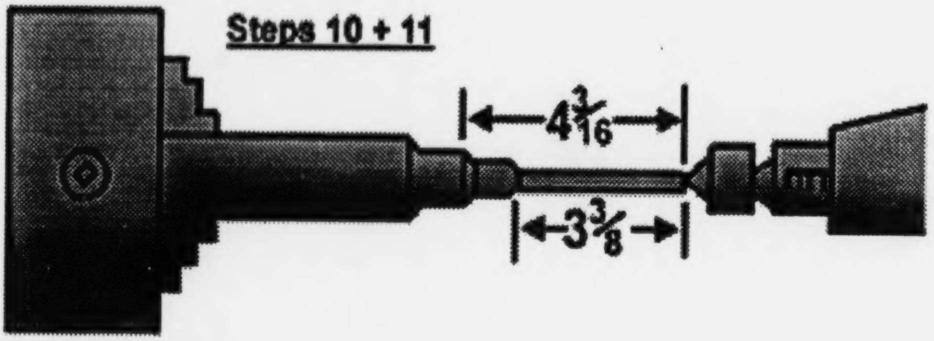

File small flat along handle in line with Jaw #1

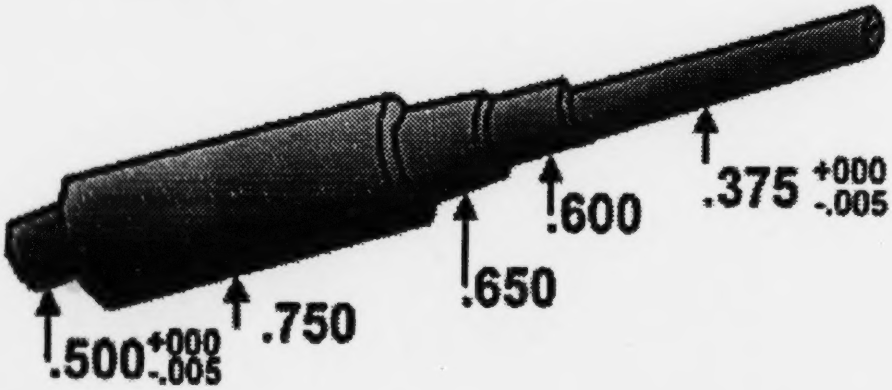

Step 8
No. 1
Chuck Jaw and Flat in Line
.750

STEP 9

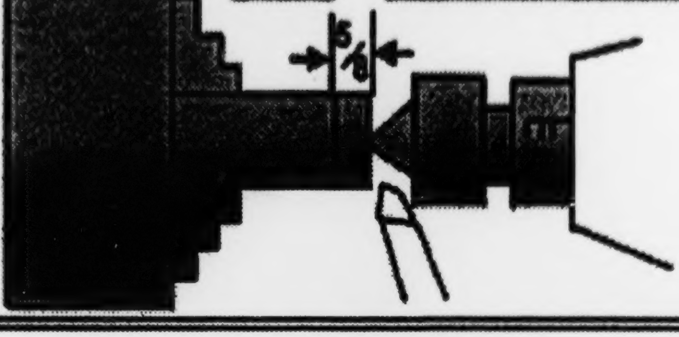

$4\frac{5}{8}$
.650

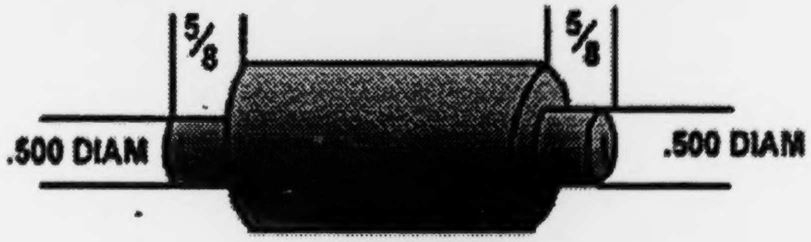
Steps 10 + 11


$4\frac{3}{16}$
$3\frac{3}{8}$

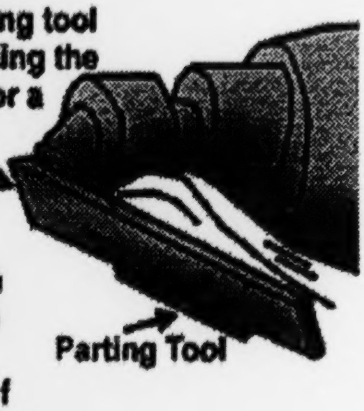

$.500^{+000}_{-.005}$
.750
.650
.600
$.375^{+000}_{-.005}$

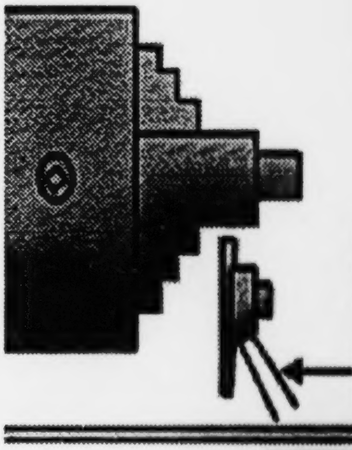
STEP 3 HAMMER HEAD PROCEDURE




5/8
5/8
.500 DIAM
.500 DIAM

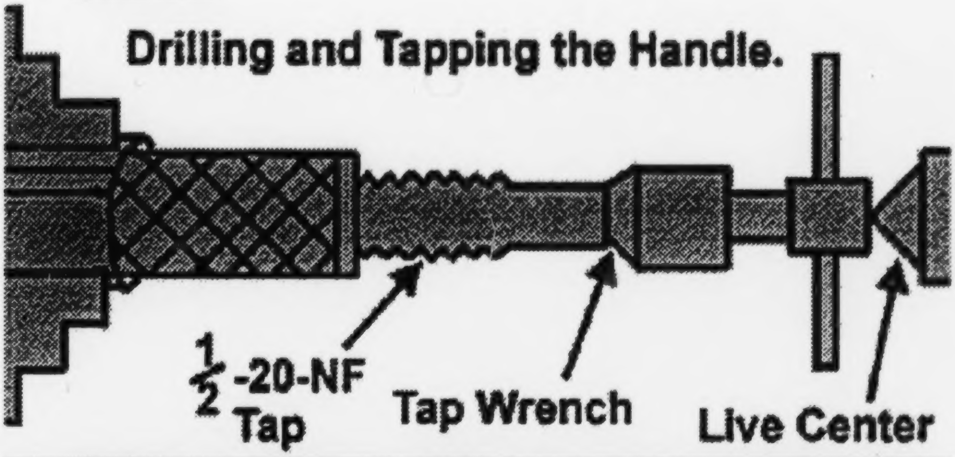
Setting parting tool on center using the live center for a gague.


Parting Tool



Measure from face of chuch to check squareness of parting tool.

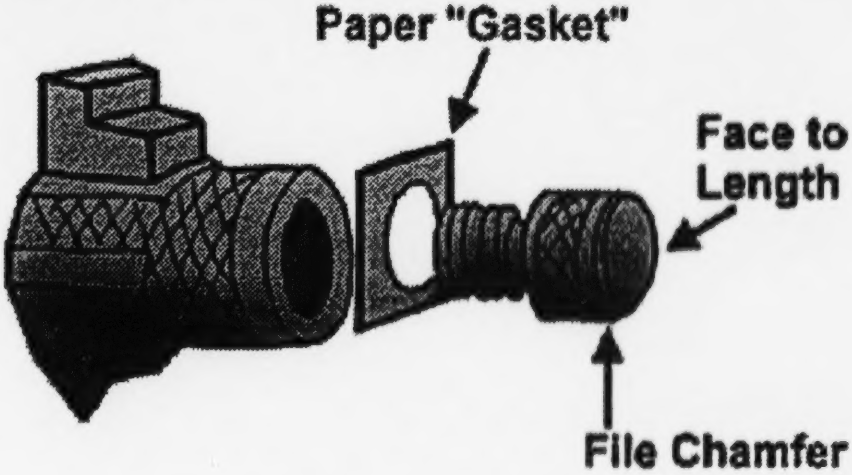
STEP 4



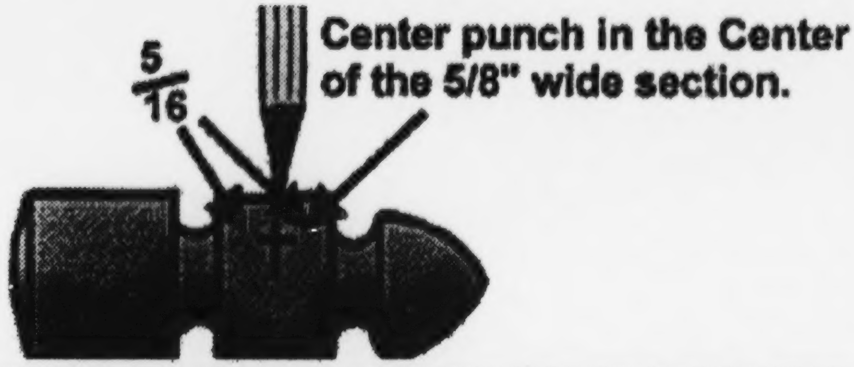
Drilling and Tapping the Handle.

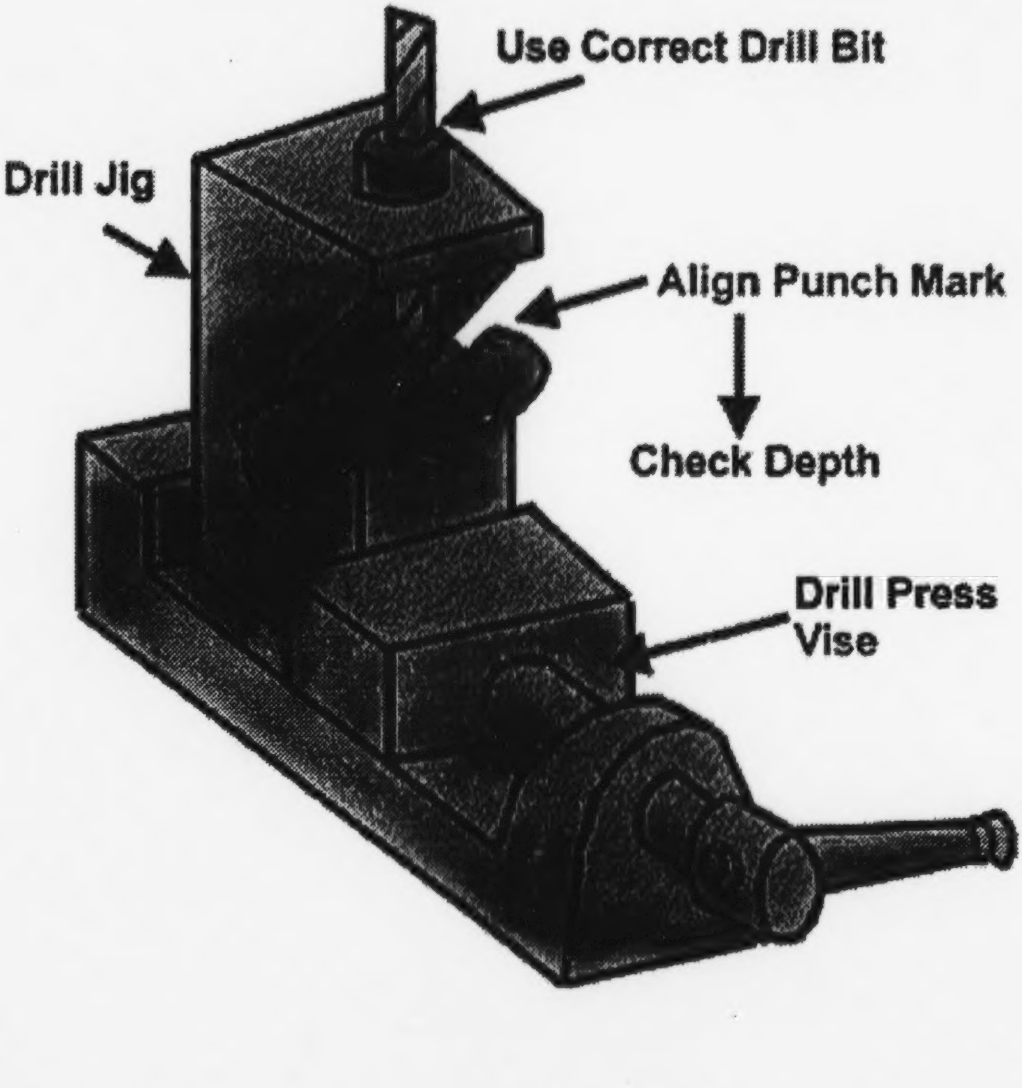
½ -20-NF Tap
Tap Wrench
Live Center

STEPS 5+6



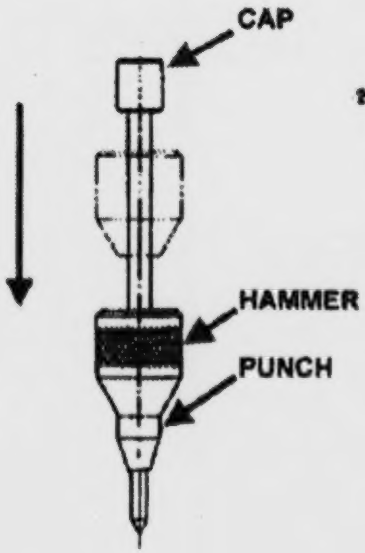
Paper "Gasket"
Face to Length
File Chamfer

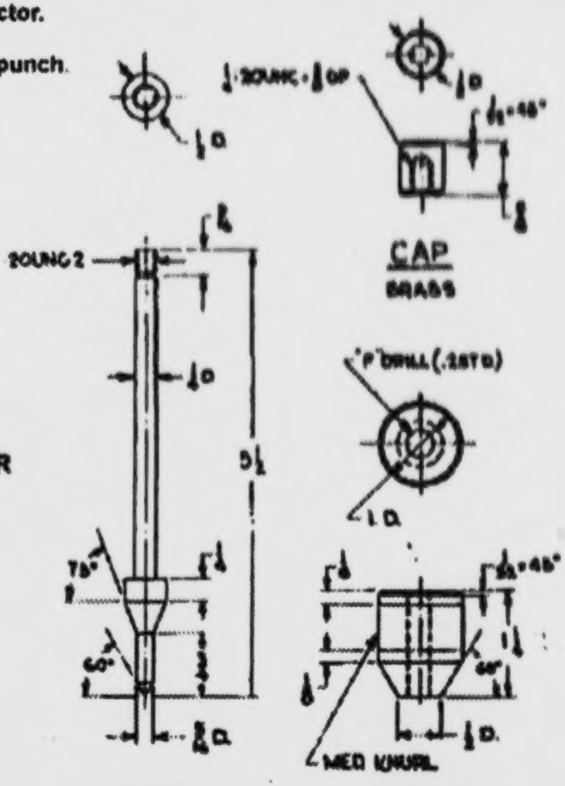

Center punch in the Center of the 5/8" wide section.
5/16


Use Correct Drill Bit
Drill Jig
Align Punch Mark
Check Depth
Drill Press Vise

1. Material: As noted.
2. Finish: Accepted machine shop practice little or no filing.
3. Tolerances: As indicated by your instructor.
4. Break all sharp edges.
5. Heat Treat only the point section of the punch.

GRAVITY CENTER PUNCH

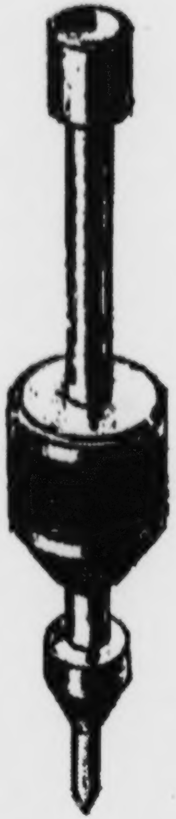

CAP
HAMMER
PUNCH


20UNC2
5½
75°
60°
20UNC
"F" DRILL (.257 D)
I.D.
45°
60°
MED KNURL

PUNCH
DRILL ROD - HEAT TREAT

CAP
BRASS

HAMMER
C.R.S.



Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-F8-HO
Operate Grinding/Abrasive Machines
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Discuss the selection and identification of grinding wheels;
b. Inspect, mount, true, dress, and balance grinding wheels;
c. Discuss common problems and solutions in surface grinding;
d. Operate horizontal spindle reciprocating table surface grinders;
e. Operate ID and OD grinders;
f. Operate honing machines; and,
g. Operate lapping machines.

Module Outline:

I. Discuss the Selection and Identification of Grinding Wheels
    A. Types of Common Abrasives
    B. Uses of Common Abrasives
    C. Coding System
    D. Types of Grinding Wheels
        1. Surface Grinders
        2. Cylindrical Grinders
II. Inspect, Mount, True, Dress, and Balance Grinding Wheels
III. Discuss Common Problems and Solutions in Surface Grinding
    A. Use and Selection of Grinding Fluids
    B. Surface Grinding is NOT Face Grinding
IV. Operate Horizontal Spindle Reciprocating Table Surface Grinders
V. Operate ID and OD Grinders
VI. Operate Honing Machines
VII. Operate Lapping Machines

MFG-F8-LE
Operate Grinding/Abrasive Machines
Attachment 2: MASTER Laboratory Exercise

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1. **Instructor will demonstrate how to setup and operate a surface grinder to a tolerance of .002 without endangering personnel of equipment.**

2. **Student will demonstrate how to setup and operate a surface grinder to a tolerance of .002 without endangering personnel of equipment.**

3. **Instructor will grade student's performance on setup and operating a surface grinder to a tolerance of .002 without endangering personnel of equipment.**

Rules of Conduct

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   c. No jewelry;
   d. Hard, closed-toe shoes;
   e. Eye protection (safety glasses); and,
   f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

Duties	← Tasks →												
A Practice Safety	A-1 Follow safety manuals and all safety regulations/requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/Control chemical hazards						
B Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/decimals	B-3 Convert Metric/English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and, angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
	B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/abrasive machines					
G Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H Program Using CAM System	H-1 Understand CAD/CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex tool-path functions								
I Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L Maintain Hydraulic/Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MFG-G1-HO
Prepare and Plan For CNC Machining Operations
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Read and interpret blueprints;
b. Understand machinability and chip formation;
c. Use the *Machinery's Handbook* as a reference for machine applications;
d. Describe the tools and toolholders will be needed for machining operations;
e. Calculate speeds, feeds, and depth of cut for various machine operations;
f. Use carbides and other tool materials;
g. Assemble work holding (fixturing) components; and,
h. Perform basic semi-precision and precision layout as necessary.

Module Outline:

I. Plan for CNC Machining Operation
  A. Read and interpret blueprints
  B. Understand machinability and chip formation
  C. Plan for raw material preparation
    1. Describe effect of material preparation on production
    2. Describe typical shapes of raw materials
    3. Describe effects of proper material preparation
    4. Describe ways to minimize wasted time and material
    5. Describe pre-machining of materials to avoid excessive CNC machine time
    6. Create material preparation plan for NC machining
  D. Use the *Machinery's Handbook* as a reference for machine applications
  E. Answer the following questions:
    1. What operations are necessary to produce the part? (qualify, rough, finish, grind, face, turn, thread, groove, etc.)
    2. What sequence of tools will be used?
    3. How will the part be fixtured? Fasteners should not interfere with machine movement. (Clamps, vise, chucks, collets, etc.)
    4. How many set-ups will be required?
    5. What is the accuracy required for machining dimensions?
  F. Plan use of machining fixtures
    1. Describe and identify various work holding devices

        2. Describe clamping principles and cautions
        3. Describe work piece locating principles
        4. Create plan for work holding devices and tooling selection on program planning sheet

II. Prepare for Machining Operations
    A. What type of tools and toolholders will be needed for roughing, finishing, etc.? Use carbides and other tool materials when available. Verify tool availability.
    B. Calculate speeds, feeds, and depth of cut for various machine operations
    C. Assemble work holding (fixturing) components
    D. Perform basic semi-precision and precision layout as necessary
    E. Load the part into the work-holding (fixturing) device

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5. Follow all institutional safety rules.

MFG-G2-HO
Select and Use CNC Tooling Systems
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Understand machinability and chip formation;
- b. Select proper insert materials and geometry;
- c. Assemble tooling components;
- d. Select correct tooling systems;
- e. Identify tooling cost factors; and,
- f. Identify and describe clamping principles and cautions.

Module Outline:

- I. Understand Machinability and Chip Formation
  - A. Machinability
    - 1. Grain Structure
    - 2. Metallic composition of workpiece
  - B. Chip formation
    - 1. Discuss the advantages of small chips vs. large chips
    - 2. Discuss *large rake angle* vs. *small rake angle*
    - 3. Discuss *positive rake angle* vs. *negative rake angle*
    - 4. Discuss *angle of keenness* and chipbreakers
  - C. Effects of heat and friction
    - 1. Discuss *red hardness* (temperatures in excess of 900°F)
    - 2. Cemented-carbide cutting tools and temperatures up to 1600°F
    - 3. Discuss how friction affects final size
  - D. Discuss the properties and use of cutting fluids
- II. Select Proper Insert Materials and Geometry
- III. Assemble Tooling Components
- IV. Select Correct Tooling Systems
  - A. List common types of tool alloys used for cutting tools
  - B. Identify advantages and disadvantages of different alloys
  - C. Evaluate prices for various alloys compared to productivity changes
  - D. Compare various tool geometries and their effects on machining
  - E. Select tooling based on various budget models
  - F. Create tool planning list showing various models
- V. Identify Tooling Cost Factors

Rules of Conduct

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    f. Ear protection (plugs or headset).
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MFG-G3-HO
Program CNC Machines
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

- a. Identify and describe essentials and safety of CNC systems;
- b. Identify and describe types of CNC hardware and software;
- c. Identify and describe machine axes and coordinate systems;
- d. Identify and describe coordinate systems;
- e. Plan and write programs for CNC mills; and,
- f. Plan and write programs for CNC lathes.

Module Outline:

- I. Identify and Describe Essentials and Safety of CNC Systems
  - A. Identify and explain essentials
    - 1. Define numerical control
    - 2. Explain history and future of CNC technology
    - 3. Identify basic elements of CNC system
    - 4. Define Computer Numerical Control (CNC)
    - 5. Explain advantages and limitations of CNC
    - 6. Identify applications of CNC technology
  - B. Compare types of CNC systems
    - 1. Identify and describe modes on numerical control systems
    - 2. Explain difference between the following:
      - a. Point-to-point
      - b. Axial path
      - c. 45° line type
      - d. Linear Path
      - e. Continuous path
    - 3. Describe CNC interpolation
    - 4. Identify types of CNC interpolations
    - 5. Explain difference between open loop and closed loop systems
    - 6. List benefits and problems of open and closed loop systems
  - C. Demonstrate safety practices related to CNC systems
    - 1. Demonstrate safety practices, including:
      - a. Safety guard/door interlocks
      - b. Power box interlocks
      - c. Tool loading and unloading
      - d. Loading and unloading work holding devices
      - e. Machine coolant disposal
    - 2. Describe/identify personal safety equipment

- II. Identify and Describe Types of CNC Hardware and Software
  - A. Identify and describe CNC hardware
    - 1. Compare NC and CNC systems
    - 2. Identify components of CNC machine control unit (MCU)
    - 3. Define applications of operator control panel
    - 4. Explain functions of operator control panel
    - 5. Define utilities found on typical control panel
    - 6. Select appropriate CNC controls
  - B. Describe CNC software
    - 1. Describe software related to machine tool
    - 2. Describe applications of operation, interface and application software
    - 3. Describe interface of software and hardware
  - C. Explain feed back drive system
    - 1. Describe feed drive system
    - 2. Explain feed back mechanisms
    - 3. Compare direct and indirect measurement systems
- III. Identify and Describe Machine Axes and Coordinate Systems
  - A. Identify and describe machine axes
    - 1. Define and identify machine axes X, Y and Z
    - 2. Identify and describe linear axes using right hand rule
    - 3. Identify and define primary rotary axes a, b and c
  - B. Describe coordinate systems
    - 1. Describe Cartesian coordinate system as used in NC program
    - 2. Define relationship of Cartesian coordinate system with machine axes
  - C. Define characteristics of positioning systems
    - 1. Define application of absolute positioning systems
    - 2. Define application of incremental positioning systems
  - D. Define reference systems
    - 1. Describe characteristics of:
      - a. Machine reference coordinates
      - b. Work reference coordinates
      - c. Program reference coordinates
      - d. Fixtures offset coordinates
- IV. Describe and Interpret CNC Coding Systems
  - A. Interpret number bases
    - 1. Interpret decimal and binary bases
    - 2. Interpret octal and hexadecimal bases
  - B. Describe NC program storage media
    - 1. Describe the media
    - 2. Describe advantages and disadvantages of each media
  - C. Describe EIA and ASCII formatted tapes
    - 1. Describe EIA format on tapes
    - 2. Describe ASCII format on tapes

3. Describe differences in EIA and ASCII formats

V. Write NC Programs

A. Create NC words
1. Define NC characters, blocks and words
2. Identify and describe commonly used NC codes
3. Describe and create safe start blocks
4. Combine NC codes to create part program

B. Create NC programs
1. Use absolute (G90) and incremental (G91) positioning
2. Use rapid positioning (G00) and linear interpolation (G01)
3. Use circular interpolation (G02) and (G03)
4. Identify plane selections (G17, G18, G19)
5. Apply proper plane selection to circular interpolation
6. Define and describe axis modifiers (I, J, K) and apply to circular interpolation (absolute and incremental type)

C. Calculate and program cutter speed and cutter compensation
1. Describe cutter compensation commands (G40, G41, G42)
2. Describe relationships associated with G41 and climb milling
3. Describe relationship associated with G42 and conventional milling
4. Evaluate reference documentation to establish machinability factors for RPM equation
5. Apply RPM calculations to identify proper spindle speed "S" word

D. Calculate and program cutter feed and depth of cut
1. Evaluate reference documentation to establish feed rate factors
2. Apply depth of cut calculations for programming efficiency
3. Apply feed equation to establish correct feed "F" word

E. Program tool selection and unit input systems
1. Describe and apply unit input code (G70 and G71) correctly
2. Describe tool function "T" word and its use
3. Describe retract quill to Z machine home "M6"
5. Describe and apply "T" word with "M6" to create tool change
6. Apply "M" codes to program
7. Describe and list common "M" words and their applications
8. Describe "M00" program stop and "M01" optional stop applications
9. Describe "M02" end of program and "M30" end of tape

F. Program spindle operation
1. Identify spindle commands
2. Describe "M03" spindle on clockwise and "M04" spindle on counterclockwise
3. Describe "M05" stop spindle
4. Identify and describe coolant commands "M07", "M08" and "M09"

        5. Apply "M" codes to program
    G. Program fixed cycles
        1. Identify and describe fixed cycles "G81 - G89"
        2. Describe benefits and time saving by using fixed cycles in programming
        3. Explain different fixed cycle formats for different controllers
        4. Apply fixed cycles to programs
    H. Program operator messages
        1. Identify and describe non-machine code "operator messages"
        2. Describe symbols to isolate operator messages from program
            a. "*"
            b. "()"
        3. Apply operator messages to NC part program as needed

VI. Student Practice - Plan and Write Programs for CNC Mills

VII. Student Practice - Plan and Write Programs for CNC Lathes

MFG-G3-LE
Program CNC Machines
Attachment 2: **MASTER** Laboratory Exercise

The students shall:

a. Plan and write programs for CNC mills; and,

b. Plan and write programs for CNC lathes.

MFG-G3-LA
Program CNC Machines
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

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    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-G4-HO
Operate CNC Machining Centers (Mills)
Attachment 1: MASTER Handout

Objectives:

Upon completion of this module the student will be able to:

- a. Describe history of vertical machining;
- b. Describe theory of operation;
- c. Describe nomenclature used in vertical machining;
- d. Demonstrate safety practices related to vertical machining centers;
- e. Set-up and program operation of vertical machine;
- f. Demonstrate proper machining of objects;
- g. Create program using machine controllers software, and cycles;
- h. Set-up and utilize three dimensional digitizer; and,
- i. Maintain vertical machine.

Module Outline:

- I. Describe Vertical Machining Process and Safety
  - A. Describe History of Vertical Machining
    - 1. Describe proper use of various machines
  - B. Describe Theory of Operation
    - 1. Describe open and closed loop systems
    - 2. Describe various oil and air requirements
    - 3. Describe how vertical machines function
  - C. Describe Nomenclature Used in Vertical Machining
    - 1. Describe common tools used to:
      - a. Mill
      - b. Single point thread
      - c. Drill
      - d. Single point bore
      - e. Tap
      - f. Reaming
    - 2. Describe solid and collet type tool holders
  - D. Demonstrate Safety Practices Related to Vertical Machining Centers
    - 1. Demonstrate operating safety practices, including:
      - a. Safety door interlocks
      - b. Machining vise loading and unloading
      - c. Power box interlocks
      - d. Machine coolant disposal
      - e. Tool loading and unloading
    - 2. Describe/identify personal safety equipment
- II. Describe Vertical Machining Functions

- A. Describe Controller Functions, including:
    - 1. Power meter
    - 2. Automatic mode
    - 3. Key lock
    - 4. Emergency stop button
    - 5. Option switches
    - 6. Manual modes:
        - a. Command mode
        - b. MDI mode
    - 7. Rapid travel over ride
    - 8. Single step mode (Block-To-Block)
    - 9. Feed rate override
    - 10. Jog mode
    - 11. Spindle speed override
    - 12. Spindle On/Off
    - 13. Axis selector
    - 14. Slide hold
    - 15. Increment of movement selector
    - 16. Coolant 1 and 2 On/Off
    - 17. Tool In/Out
    - 18. Start button
    - 19. Turret clockwise (CW) and turret counterclockwise (CCW)
    - 20. Start function

III. Set-Up and Program Operation of Vertical Machine

- A. Describe machine tool limitations, including:
    - 1. Number of possible tools
    - 2. Limits in X,Y and Z axes
    - 3. Maximum spindle speed and horsepower
    - 4. Memory size in controller
    - 5. Fast feed rate
    - 6. Oil and air requirements
    - 7. Rapid positioning rate
    - 8. Communication systems
- B. Perform basic machine set-up
    - 1. Check oil and air supply
    - 2. Set tool changer numbers
    - 3. Turn power on
    - 4. Mount machine vise on machine table
    - 5. Set machine home position
    - 6. Indicate vise to within specified tolerances
    - 7. Load tools into proper tool holders
    - 8. Load part into vise
    - 9. Load tools into tool carousel
        - a. Load tools using spindle
        - b. Load tools directly into carousel

- C. Set part home
    - 1. Set part home using edge finder
    - 2. Set part home using test indicator and gauge block
    - 3. Set part home from tooling ball using fixture offsets
- D. Set tool length offsets
    - 1. Set tool length offsets using work piece
    - 2. Set tool length offsets using gauge block
    - 3. Set tool length offsets using electronic probe
    - 4. Set tool length offsets using keyboard commands
    - 5. Modify length and diameter offsets using tool page editor.
    - 6. Upload and download tool information to storage
- E. Load program
    - 1. Upload and download programs using RS-232 interface
    - 2. Upload and download programs using local area network
- F. Edit program for machine tool
    - 1. Edit program at machine tool using editor in controller
    - 2. Edit program using DOS and Windows editors
- G. Create program without CAD/CAM for common machine operations using machine controllers software to include:
    - 1. Proper use of cutter compensation
    - 2. Fixed cycles
    - 3. Fixed sub-routines
    - 4. Sub-routines (loops)
    - 5. Fixture offsets
    - 6. Trouble shoot and repair problems in programs
    - 7. Use machine verification options if available

IV. Demonstrate Machining of Objects on Vertical Machining Center

- A. Machine objects, including:
    - 1. Outside contours
    - 2. Pockets
    - 3. Drilled holes
    - 4. Drill and tapped holes
        - a. Rigid tapping
        - b. Compression tapping
    - 5. Single point boring
    - 6. Reaming
    - 7. Single point thread, internal and external
- B. Set-up three dimensional digitizer and machine model
    - 1. Mount model on machine table
    - 2. Install 3-dimensional digitizing unit
    - 3. Establish communications with computer
    - 4. Define grid pattern and feed rate required for given tolerances
    - 5. Set part home
    - 6. Digitize model
    - 7. Process digital data for machining

   8. Machine new model with program created from digitizer
- C. Create work piece using 4th- and 5th-axes
   1. Mount, connect and indicate 4th- and 5th-axes attachment
   2. Set-tooling
   3. Machine work piece
   4. Remove 4th- and 5th-axes attachment
- D. Maintain vertical machine
   1. Mix coolant
   2. Determine need for coolant change
   3. Change coolant
   4. Clean coolant tank
   5. Clean machine
   6. Change oil filters
   7. Add lubricating fluid
   8. Add hydraulic fluid
   9. Dispose of coolant and oils per EPA regulations

MFG-G4-LE/SA
Operate CNC Machining Centers (Mills)
Attachment 2: MASTER Laboratory Exercise/Self-Assessment

Note to the Instructor:

Because of the wide variety of CNC machining centers and CNC mills available, student laboratory and assessment activities must be developed by the instructor for his or her particular laboratory equipment. All laboratory exercises and student assessments should be "hands on" which stress machine safety and assess the student's mastery of each of the lesson objectives.

MFG-G4-LA
Operate CNC Machining Centers (Mills)
Attachment 3: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-G5-HO
Operate CNC Turning Centers (Lathes)
Attachment 1: MASTER Handout

Objectives:

Upon completion of this module the student will be able to:

- a. Describe history of horizontal turning centers;
- b. Describe theory of operation;
- c. Describe nomenclature used in horizontal turning centers;
- d. Demonstrate safety practices related to horizontal turning centers;
- e. Set-up and program operation of horizontal turning centers;
- f. Demonstrate proper machining of objects;
- g. Create program using machine controllers software; and,
- h. Maintain horizontal turning centers.

Module Outline:

- I. Explain CNC Turning Process, Equipment and Safety
  - A. Describe CNC turning process
    - 1. Describe history of CNC turning
    - 2. Describe use of various turning machines
  - B. Describe theory of operation
    - 1. Describe open and closed loop systems
    - 2. Describe various oil and air requirements
    - 3. Describe how turning centers function
  - C. Describe nomenclature used in CNC turning
    - 1. Describe and identify common tools used to:
      - a. Turn
      - b. Drill
      - c. Groove
      - d. Face
      - e. Bore
      - f. Single point thread
      - g. Tap
    - 2. Describe and identify work holding devices used in turning, including:
      - a. 2-jaw chucks
      - b. 3-jaw chuck
      - c. 4-jaw chucks
      - d. Soft jaw chucks
      - e. Bar feed attachments
      - f. Collets
      - g. Centers

- 3. Select proper cutting inserts relative to:
  - a. Roughing
  - b. Finishing
  - c. Threading
  - d. Different types of materials
- D. Demonstrate safety practices related to CNC turning centers
  - 1. Demonstrate operating safety practices, including:
    - a. Safety door interlocks
    - b. Power box interlocks
    - c. Tool loading and unloading
    - d. Loading and unloading work holding devices
    - e. Machine coolant disposal
  - 2. Describe/identify personal safety equipment

- II. Describe CNC Turning Center
  - A. Describe controller functions, including:
    - 1. Power meter
    - 2. Option switches
    - 3. Key lock
    - 4. Emergency stop button
    - 5. Rapid travel override
    - 6. Feed rate override
    - 7. Spindle speed override
    - 8. Axis selector
    - 9. Increment of movement selector
    - 10. Slide hold
    - 11. Start function
  - B. Describe keyboard functions, including:
    - 1. Automatic mode
    - 2. Manual MDI mode
    - 3. Single step mode (block-to-block)
    - 4. Jog mode
    - 5. Spindle on/off
    - 6. Coolant on/off
    - 7. Tool turret clockwise (CW) and tool turret counterclockwise (CCW)
- III. Set-Up and Program Operation of CNC Turning Center
  - A. Describe machine tool limitations, including:
    - 1. Number of possible tools
    - 2. Maximum spindle speed and horsepower
    - 3. Fast feed rate
    - 4. Rapid positioning rate
    - 5. Limits in X and Z axes
    - 6. Memory size in controller
    - 7. Oil and air requirements
    - 8. Communication systems

B. Perform basic machine set-up
   1. Check oil and air supply
   2. Turn power on
   3. Set machine home position
   4. Load tools into proper tool holders
   5. Load tools into tool carousel
   6. Set tool changer numbers
   7. Mount work piece into chuck
   8. Indicate work piece within specified tolerances

C. Set tool length offsets
   1. Set tool length offsets using work piece
   2. Set tool length offsets using keyboard commands
   3. Modify length and diameter offsets using tool page editor
   4. Modify length and diameter offsets using keyboard
   5. Upload and download tool information to storage

D. Load program
   1. Upload and download programs using RS-232 interface
   2. Upload and download programs using local area network

E. Edit program for machine tool
   1. Edit program at machine tool using editor in controller
   2. Edit program using DOS and Windows editors

IV. Create Program Without CAD/CAM for Common Machine Operations Using Machine Controllers Software to include:
A. Proper use of cutter compensation
B. Fixed cycles
C. Fixed sub-routines
D. Sub-routines (loops)
E. Fixture offsets
F. Trouble shoot and repair problems in programs
G. Use machine verification options if available

V. Create Program for Common Machine Operations
A. Use machine controller editor
B. Use DOS editor
C. Use Windows editor

VI. Demonstrate Machining of Objects on CNC Turning Center
A. Machine objects, including:
   1. External and internal contouring
   2. External and internal grooving
   3. Drill and tapped holes
   4. Single point boring
   5. Reaming
   6. Single point thread internal and external
   7. Facing operations
   8. Turning tapers

B. Maintain turning center

1. Mix coolant
2. Determine need for coolant change
3. Change coolant
4. Clean coolant tank
5. Clean machine
6. Change oil filters
7. Add lubricating fluid
8. Add hydraulic fluid
9. Dispose of coolant and oils per EPA regulations

MFG-G5-LE/SA
Operate CNC Turning Centers (Lathes)
Attachment 2: MASTER Laboratory Exercise/Self-Assessment

Note to the Instructor:

Because of the wide variety of CNC machining centers and CNC mills available, student laboratory and assessment activities must be developed by the instructor for his or her particular laboratory equipment. All laboratory exercises and student assessments should be "hands on" which stress machine safety and assess the student's mastery of each of the lesson objectives.

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-G6-HO
Program CNC Machines Using a CAM System
Attachment 1: MASTER Handout

Objectives:

Upon completion of this unit the student will be able to:
1. Access CAD program options; and,
2. Create basic geometric entities.

Module Outline:

- I. Access CAD Program Options
  - A. Explain the configuration of CAD/CAM software
    - 1. Explain configuration of:
      - a File and path names
      - b. Installation, including DOS and Windows
      - c. Configure software
      - d. Interaction of files between each other
    - 2. Describe the "flow" process of CAD/CAM
  - B. Access CAD software
    - 1. Access CAD software, including AutoCAD and CadKey, to:
      - a. Create basic 2-dimensional designs
      - b. Create 3-dimension designs
      - c. Dimension designs to be used as drawings
      - d. Create title blocks and borders for prints
      - e. Print drawings
      - f. Plot drawings
      - g. Create general and local drawing notes and tolerances
    - 2. Describe various file conversion formats
    - 3. Import and export designs using conversions, including:
      - a. IGES
      - b. CADL
      - c. DXF
      - d. STL
  - C. Access CAM software
    - 1. Load existing design
    - 2. Import and export design files from various file format standards, including:
      - a. IGES
      - b. DXF
      - c. CADL
      - d. STL
    - 3. Save design files to "permanent" memory

4. Access CAD section of CAM software to create
    a. Create basic 2-dimensional designs
    b. Create 3-dimension designs
    c. Dimension designs to be used as drawings
    d. Create title blocks and borders for prints
    e. Print drawings
    f. Plot drawings
    g. Create general and local drawing notes and tolerances

II. Create Basic Geometric Entities
  A. Create basic geometric entities, including:
    1. Points
    2. Fillets
    3. Lines
    4. Splines
    5. Arcs
    6. Chamfers
    7. Circles
    8. Letters including various machinable fonts
  B. Dimension completed designs to create detailed drawings
  C. Transform geometric entities using CAD commands
    1. Transform geometric entities, including:
      a. Mirror entities
      b. Rotate entities
      c. Scale complete entities using single scale option
      d. Translate using move and copy options
      e. Offset single and grouped geometric entities
      f. Use group function to effect multiple entities simultaneously
      g. Use result function to effect group movements
  D. Set menu selections to:
    1. View planes
    2. Construction planes
    3. Color choices
  E. Use Delete command:
    1. Use Delete commands, including:
      a. Chained and duplicate entities
      b. Exclusive entities (only)
      c. Inclusive entities (all)
      d. Enclosed in window
      e. Intersecting window
  F. Execute screen and display functions
    1. Use screen and display functions to:
      a. List screen statistics
      b. Display entity endpoints
      c. Clear group and result color designation

d. Change colors of entities
e. Display window
f. Un-zoom display
g. Change levels of entities
h. Fit entities to screen
i. Set various view ports
j. Refresh screen
k. Change views
l. Set active levels
m. Change entities between levels
m. Set screen center "pan"
n. Initialize display "clear"
o. Rotate display

G. Use analyze function
1. Use analyze function to interpret:
   a. Point descriptions
   b. Single entity information
   c. Locations of entities
   d. Distance between points
   e. Area calculations
   f. Calculation of angles

MFG-G6-LA
Program CNC Machines Using a CAM System
Attachment 2: **MASTER** Laboratory Aid

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MFG-G7-HO
Download Programs Via Network
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Download programs from the network;
b. Upload programs to the network; and,
c. Perform edit and print functions via the network.

Module Outline:

I. Download Programs from the Network
    A. The CNC machine control and computer network must be properly connected (see Machine Operator's Manual)
    B. CNC programs must be copied into the proper file directory or folder
    C. Network software must be configured to "Send (download) Files" from file folder or directory to the machine controller
    C. CNC machine must be set to "Load Program"
    D. Verify that the program has been loaded into the CNC machine control unit and is available to run the machine
II. Upload Programs to the Network
    A. CNC machine control and computer network must be properly connected (see Machine Operator's Manual)
    B. Network software must be configured to "Receive (upload) Files" from machine controller to the network file folder or directory
    C. CNC machine must be set to "Send Program"
    D. Send program from machine control unit to network folder or directory
    D. Verify that the program has been copied into the network folder or directory
III. Perform Edit and Print Functions Via the Network

Rules of Conduct

1. Absolutely no horseplay or practical joking will be tolerated.
2. Do not talk to anyone who is operating a machine.
3. Walk only in the designated traffic lanes.
4. Dress appropriately; at the absolute minimum, you must have:
    a. No loose clothing, including ties;
    b. Long hair properly stowed;
    c. No jewelry;
    d. Hard, closed-toe shoes;
    e. Eye protection (safety glasses); and,
    f. Ear protection (plugs or headset).
5. Follow all institutional safety rules.

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

Duties	Tasks												
A Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
	B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

1405

1406

MFG-H1-HO
Understand CAD/CAM Programs
Attachment 1: **MASTER** Handout

Objective(s):

Upon completion of this module the student will be able to:

a. Describe various CAD/CAM software;
b. Describe differences between CAD/CAM;
c. Discuss various software packages; and,
d. Describe various requirements for CAD/CAM software.

Module Outline:

I. Demonstrate Understanding of CAD/CAM Programs
  A. Explain CAD/CAM programs
    1. Define Computer Aided Design (CAD)
    2. Define Computer Aided Manufacturing (CAM)
    3. Describe common applications of CAD and CAM
    4. Discuss common CAD packages to include:
      a. AutoCAD
      b. CadKey
      c. Micro Station
    5. Discuss Common CAM packages to include:
      a. MasterCam
      b. SurfCam
      c. SmartCam
    6. Describe common applications of CAD package design areas
      a. Architectural
      b. Electronics
      c. Mechanical
  B. Discuss various design modeling databases
    1. Wire Frame
    2. Surface Models
    3. Solid Models
II. Describe Various Abilities of CAD/CAM
  A. Discuss common applications of CAM software for:
    1. Vertical Machining applications
    2. Turning applications
    3. Grinding applications
    4. E.D.M. Applications
  B. Discuss benefits of using:
    1. Wire Frame
    2. Surface Models

        3. Solid Models
    C. Discuss flexibility and increased production for application of:
        1. CAD for Design
        2. CAM for Manufacturing

III. Describe Various Requirements for CAD/CAM Software
    A. Computer hardware
    B. Computer operating systems
    C. Education/Training

MFG-H2-HO
Manipulate CAD Functions
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to:

- **a. Demonstrate the correct use of CAD/CAM software to generate basic 2-dimensional shapes; and,**
- **b. Demonstrate the correct use of CAD/CAM software to generate basic 3-dimensional shapes.**

Module Outline:

- I. Access CAD Program Options
  - A. Explain the configuration of CAD/CAM software
    - 1. Explain configuration of:
      - a File and path names
      - b. Installation, including DOS and Windows
      - c. Configure software
      - d. Interaction of files between each other
    - 2. Describe the "flow" process of CAD/CAM
  - B. Access CAD software
    - 1. Access CAD software, including AutoCAD and CadKey, to:
      - a. Create basic 2-dimensional designs
      - b. Create 3-dimension designs
      - c. Dimension designs to be used as drawings
      - d. Create title blocks and borders for prints
      - e. Print drawings
      - f. Plot drawings
      - g. Create general and local drawing notes and tolerances
    - 2. Describe various file conversion formats
    - 3. Import and export designs using conversions, including:
      - a. IGES
      - b. CADL
      - c. DXF
      - d. STL
  - C. Access CAM software
    - 1. Load existing design
    - 2. Import and export design files from various file format standards, including:
      - a. IGES
      - b. DXF
      - c. CADL

d. STL

3. Save design files to “permanent” memory
4. Access CAD section of CAM software to create
   - a. Create basic 2-dimensional designs
   - b. Create 3-dimension designs
   - c. Dimension designs to be used as drawings
   - d. Create title blocks and borders for prints
   - e. Print drawings
   - f. Plot drawings
   - g. Create general and local drawing notes and tolerances

II. Create Basic Geometric Entities
   - A. Create basic geometric entities, including:
     1. Points
     2. Fillets
     3. Lines
     4. Splines
     5. Arcs
     6. Chamfers
     7. Circles
     8. Letters including various machinable fonts
   - B. Dimension completed designs to create detailed drawings
   - C. Transform geometric entities using CAD commands
     1. Transform geometric entities, including:
        - a. Mirror entities
        - b. Rotate entities
        - c. Scale complete entities using single scale option
        - d. Translate using move and copy options
        - e. Offset single and grouped geometric entities
        - f. Use group function to effect multiple entities simultaneously
        - g. Use result function to effect group movements
   - D. Set menu selections to:
     1. View planes
     2. Construction planes
     3. Color choices
   - E. Use Delete command:
     1. Use Delete commands, including:
        - a. Chained and duplicate entities
        - b. Exclusive entities (only)
        - c. Inclusive entities (all)
        - d. Enclosed in window
        - e. Intersecting window
   - F. Execute screen and display functions
     1. Use screen and display functions to:
        - a. List screen statistics

- b. Display entity endpoints
- c. Clear group and result color designation
- d. Change colors of entities
- e. Display window
- f. Un-zoom display
- g. Change levels of entities
- h. Fit entities to screen
- i. Set various view ports
- j. Refresh screen
- k. Change views
- l. Set active levels
- m. Change entities between levels
- m. Set screen center "pan"
- n. Initialize display "clear"
- o. Rotate display

G. Use analyze function

- 1. Use analyze function to interpret:
  - a. Point descriptions
  - b. Single entity information
  - c. Locations of entities
  - d. Distance between points
  - e. Area calculations
  - f. Calculation of angles

MFG-H3-HO
Process Simple Toolpath Data
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to:

a. Properly identify various parts of CNC program generation;
b. Demonstrate the use of the post-processor and co-processor for intermediate CNC data;
c. Perform editing of CNC programs using various software; and
d. Perform verification of completed toolpaths.

Module Outline:

I. Generate Numerical (NC) Code
  A. Generate NC code to access:
    1. Turning center "lathe"
    2. Vertical machining center "mill"
II. Generate Basic Vertical Machining Code
  A. Generate basic vertical machining code for operations, including:
    1. Outside and inside contours
    2. Pocketing operations
      a. Islands
      b. Multiple "Z" level islands
    3. Drilling, reaming, spot drilling, tapping operations
III. Program Lathe or Turning Operations
  A. Use CAD section to create geometric designs
  B. Create lathe tools as required
  C. Create toolpath information to rough and finish
    1. Create toolpath information to rough and finish during:
      a. Turning operations
      b. Facing operations
      c. Grooving operations
      d. Internal boring operations / external boring operations
      e. Internal and external threading
  D. Edit toolpath data files
    1. View and edit tool path data files, including:
      a. Display centerline tool path
      b. Calculate time to machine
      c. Filter tool path data to reduce size and time
      d. Change feed rates and compare results
      e. Edit tool path data to change possible variables
      f. Define tool selections and operating parameters

        g. Define materials to be machined
        h. Create set-up document
    2. Verify toolpaths by cutting part as solid model
    3. Verify toolpaths by "backplotting" toolpaths

E. Process Tool Path Data to Numerical Control Code
    1. Select post processing file relative to machine tool being used
    2. Execute post processing function
    3. Edit numerical control program if needed

F. Describe and Execute Post-Processor or Co-processor Functions
    1. Describe post-processor and co-processor functions
    2. Run processors

MFG-H4-HO
Create Advanced Surface Models
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to demonstrate the correct use of CAD/CAM software to create 2- and 3-dimensional geometric shapes and surface models.

Module Outline:

I. Create Advanced Designs with CAD Section of CAD/CAM Program
  A. Create advanced geometric surfaces
    1. Create advanced geometric surfaces to include:
      a. Lofted / *Cross Section*
      b. Blend
      c. Swept / *Drive Curve*
      d. Trim
      e. Coons / *4-Curve*
      f. Draft
      g. Offset
      h. Nurb Surface
      i. Fillet
      j. Parametric Surface
  B. Edit geometric entities
    1. Modify and edit advanced geometric surfaces to include:
      a. Trimming
      b. Breaking
      c. Joining
      d. Fillet
  C. Edit advanced geometric surfaces
    1. Modify and edit advanced geometric surfaces to include:
      a. Control points of nurbs
      b. Conversion to nurbs entity
      c. Extend entities
      d. Drag entities
      e. Edit entities
    2. Change cutter offset side
    3. Change cutting directions
    4. Turn surface normal arrows on and off
    5. Decompose composite surfaces
    6. Twist vectors of parametric surface
    7. Create polygons on surface

        8. Align surface normals
        9. Trim surfaces
        10. Untrim trimmed surfaces
D. Transform geometric entities using CAD commands
    1. Scale X, Y, and Z at possible separate ratios
E. Execute screen and display functions
    1. Use screen and display functions to:
        a. Change surface density
        b. Shade surface models
        c. Blank and unblank entities

MFG-H5-HO
Process Complex Toolpath Functions
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to:

1. Demonstrate an understanding of the use of single surface machining;
2. Demonstrate an understanding of the use of multiple surface machining;
3. Demonstrate an understanding of the use of multiple tool planes and multi-axis machining; and,
4. Digitize existing objects to create new toolpaths.

Module Outline:

- I. Process Tool Path Data
  - A. Generate advanced vertical machining code
    - 1. Generate code for three axis surface machining to include:
      - a. Single surface machining,
        - 1) Create roughing toolpaths
        - 2) Create finishing toolpaths
      - b. Multiple surface machining
        - 1) Create roughing toolpaths
        - 2) Create finishing toolpaths
    - 2. Generate code for four and five-axis surface machining to include:
      - a. Single surface machining
        - 1) Create roughing toolpaths
        - 2) Create finishing toolpaths
      - b. Multiple surface machining
        - 1) Create roughing toolpaths
        - 2) Create finishing toolpaths
  - B. Import and machine scanned data
    - 1. Import and machine three-dimensional data
      - a. Collect data points using C.M.M.
      - b. Collect data using vertical machining center and digitizing probe
      - c. Convert scanned data into usable geometric entities
      - d. Create appropriate surface types from wireframes
      - e. Generate numerical control programs using surface models
  - C. Verify toolpaths
    - 1. Verify multi-surface toolpaths

   2. Verify 4th and 5th axis machine code

D. Describe and execute post-processor or co-processor functions
   1. Edit processors for 4th and 5th axis machining
   2. Process intermediate files into NC code

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	Duties	Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MFG PM4
01/2000

MFG-I1-HO
Use Computer Operating Systems
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to:

- a. Distinguish between a directory/file folder and a file;
- b. Understand data organization and terminology;
- c. Explain the function of an operating system;
- d. Explain what the term "IBM compatible" means;
- e. Use a mouse;
- f. Utilize file manager in Windows 3.1 to view directories and files;
- g. Utilize explorer in Windows 95 to view folders and files; and,
- h. Explain and use basic network concepts.

Module Outline:

- I. Introduction to Computers
  - A. Discuss hardware components
  - B. Explain disk drive configurations
  - C. Discuss software
    - 1. Application programs
    - 2. Operating systems
      - a. DOS
      - b. Windows
      - c. Windows 95
      - d. Network operating systems
  - D. Discuss brands of computers
    - 1. Apple & MacIntosh
    - 2. IBM & compatibles
  - E. Explain data organization
    - 1. Files
    - 2. Filenames and extensions
    - 3. Root directory & backward slash (\)
    - 4. Directory and subdirectory structure
  - F. Explain the terms directory path and file specification
- II. Introduction to the Windows Operating System
  - A. Discuss how to start Windows
  - B. Discuss basic mouse operations
    - 1. Pointing
    - 2. Clicking
    - 3. Double clicking
    - 4. Dragging

- C. Discuss Windows elements
  - 1. Window borders
  - 2. Title bar
  - 3. Control-menu box
  - 4. Mouse pointer
  - 5. Sizing buttons
  - 6. Scroll bar and arrows
  - 7. Menu bar
  - 8. Pull-down menus
  - 9. Work area
  - 10. Icons
- D. Use File Manager
  - 1. Explain the file manager screen
  - 2. Change drives
  - 3. Expand directories
  - 4. Collapse directories
  - 5. Change file information displayed
  - 6. Run an application
- E. Run an application from an icon in Program Manager

- III. Introduction to Windows 95 Operating System
  - A. Discuss Windows 95 desktop components
    - 1. My Computer icon
    - 2. Recycle Bin icon
    - 3. Network Neighborhood icon
    - 4. Start button
    - 5. Taskbar
  - B. Use Windows 95
    - 1. Open a window from an icon
    - 2. Use sizing buttons and close button
    - 3. Discuss Start menu
    - 4. Open an application using the Start button
    - 5. Explain shut down menu under Start
    - 6. Use Windows Explorer
      - a. Explain Windows Explorer toolbar buttons
      - b. Explain folders and subfolders
      - c. Select folders
      - d. Open and close folders
      - e. Change drives
      - f. Change file list display
- IV. Introduction to Computer Network Systems
  - A. Explain what a network is
  - B. Discuss basic network components
    - 1. File server
    - 2. Network operating system (NOS)
    - 3. Local area network (LAN) cable

    4. Network devices
- C. Explain types of networks
    1. Campus
    2. National
    3. International
- D. Explain and use basic network concepts
    1. File server login/logout
    2. Application sharing
    3. Document sharing
    4. Electronic mail

MFG-I1-LW1
Use Computer Operating Systems
Attachment 2: **MASTER** Laboratory Worksheet No. 1

Introduction to Using Windows 3.1

1. Double-click the Main Group and open the File Manager. Click Tree and choose Indicate Expandable Branches, if it has not been selected. What lets you know this selection has been made? What does this selection do?

   ____

2. Select the root of drive C. Choose Tree from the command bar. Then clock Collapse Branch. What does this selection do?

   ____

3. Choose Tree again and click Expand One Level. How many directories/folders are on drive C?

   ____

4. In the command bar, select Tree and choose Expand All. What happened?

   ____

5. Find the folder WPWIN. How many subdirectories/subfolders are listed under the directory/folder name TEMPLATE?

   ____

6. Double-click a directory/folder that contains a subdirectory/subfolder. What happened?

   ____

7. What happens if you double-click the folder again?

   ____

8. Place a disk in drive A. How can you view the contents of the file in drive A?

   ____

9. Select drive C again. Under View, choose All File Details. What happened?

   ____

10. Select the MACROS subdirectory/subfolder under WPWIN. Go to View and choose Sort by Name. What is the first file listed?________________________

    Sort by Type. The first file listed is ______________________________

Sort by Size. The first file listed is ________________________________

Sort by Date. The first file listed is ________________________________

11. How can the list of files in a particular folder be viewed?

____

12. Exit File Manager and close the Main Group. How did you do this?

____

13. How could an application package, such as WordPerfect for Windows, be loaded and run from Windows 3.1?

____

MFG-I1-LW2
Use Computer Operating Systems
Attachment 3: **MASTER** Laboratory Worksheet No. 2

Introduction to Using Windows 95

1. Click Start, go to Programs, and click Windows Explorer.

2. Maximize the window, if necessary.

3. Click in the square to the left of the My Computer icon.

4. What does a + in the square mean? What happens when you click the +?
   ____

5. What does a - in the square mean? What happens when you click the -?
   ____

6. Click on C:. How many directories/folders are at the root of drive C? How many files are at the root of drive C?
   ____

7. Expand drive C. How may directories under drive C are expandable?
   ____

8. How do you expand and collapse directories/folders?
   ____

9. Click View and select Details, what happened?
   ____

10. Put a disk in drive A and select drive A. How many directories/folders and files are at the root of drive A?
    ____

11. Select drive C again and open the DOS folder. How can you sort the file list by name, type, size, or date?
    ____

12. Exit Explorer. How did you do this?
    ____

13. How do you run an application package, such as WordPerfect, from Windows 95?

____

MFG-I1-LW3
Using Computer Operating Systems
Attachment 4: **MASTER** Laboratory Worksheet No. 3

Introduction to Using Networks

1. Locate the file server? Where is it?

   ____

2. What type of NOS is being used in this lab?

   ____

3. How do you login to the file server? What is the purpose of this?

   ____

4. Can you send an e-mail message in this lab? If so, what steps must be taken to do this?

   ____

5. What type of "sharing" can be done?

   ____

6. How can the directory structure of the file server be viewed?

   ____

7. Logout of the network. What is the purpose of this?

   ____

MFG-I2-HO
Understand Computer Terminology
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Explain what RAM is;
b. Explain what ROM is;
c. Explain memory caching;
d. Define and convert bytes, kilobytes, and megabytes;
e. Discuss the function of a central processing unit;
f. Discuss processor speed; and,
g. Understand RS-232 protocol.

Module Outline:

I. Explain What Memory Is
  A. RAM
  B. ROM
  C. Cache memory
  D. Measuring memory
    1. Byte
    2. Kilobyte
    3. Megabyte
II. Discuss Purpose and Function Of:
  A. Central Processing Units (CPUs)
  B. Processor performance
    1. Speed
    2. Generation
    3. Type
  C. RS-232 serial port
III. Determine the Amount of Available Memory on a System
  A. Choose About from the Help menu in Program Manager for Windows 3.1
  B. Choose About from the Help menu in Windows Explorer for Windows 95

MFG-I3-HO
Use File Management Systems
Attachment 1: MASTER Handout

Objectives:

Upon completion of this unit the student will be able to:
- a. Explain file management concepts;
- b. Create and delete directories/folders;
- c. Copy a file(s) from one directory to another;
- d. Copy a file(s) between a floppy disk and a hard drive;
- e. Rename, move, and delete a file(s); and,
- f. Format disks and make system disks.

Module Outline:

- I. Explain and Discuss File Management Concepts
  - A. Copying a file(s)
  - B. Deleting a file(s)
  - C. Moving a file(s)
  - D. Renaming a file(s)
  - E. Creating a directory
  - F. Deleting a directory
  - G. Copying a disk
  - H. Formatting a disk
  - I. Making a system disk
- II. Use File Manager in Windows 3.1 to Perform File Management Operations
  - A. Use the file menu to:
    - 1. Create a directory
      - a. On the hard drive
      - b. On a floppy disk
    - 2. Copy a file(s)
      - a. From one directory to another
      - b. From a floppy disk to the hard drive
      - c. From the hard drive to a floppy disk
    - 3. Move a file(s)
    - 4. Rename a file(s)
    - 5. Delete a file(s)
    - 6. Delete a directory
  - B. Use the disk menu to:
    - 1. Copy a disk
    - 2. Format a disk
    - 3. Make a system disk
- III. Use Windows 95 to Perform File Management Operations

A. Use the file menu in Windows Explorer to:
    1. Create a new folder on the hard drive
    2. Create a new folder on the floppy drive
B. Use the edit menu in Windows Explorer to:
    1. Copy a file(s) from one directory to another
    2. Copy a file(s) from a floppy disk to the hard drive
    3. Copy a file(s) from the hard drive to a floppy disk
    3. Cut a file(s)
    4. Paste a file(s)
C. Use the file menu in Windows Explorer to:
    1. Rename a file(s)
    2. Delete a file(s)
    3. Delete a folder
D. Use My Computer on the Windows 95 desktop to:
    1. Format a disk
    2. Make a system disk

MFG-13-LW1
Use File Management Systems
Attachment 2: **MASTER** Laboratory Worksheet No. 1

Using Windows 3.1 to Perform File Management Operations

*** A DATA DISK WILL BE NEEDED TO COMPLETE THESE EXERCISES. ***

1. Open the Main window and start File Manager.
2. Maximize the directory tree window.
3. View the contents of drive A and create a directory called RAINBOW.
4. View the contents of the hard drive by selecting the root icon for drive C.
5. Expand the directory named WINDOWS and view the files in the SYSTEM subdirectory.
6. Sort the files in SYSTEM by size and select the four smallest files.
7. Copy these files to the RAINBOW directory on drive A.
8. Check to see that these four files are still in the SYSTEM subdirectory. Now, view the contents of the RAINBOW directory on drive A to make sure the files were copied.
9. Rename each of the files under RAINBOW on drive A as Red, Blue, Green, and Yellow.
10. Create another directory on drive A named COLORS.
11. Move the files Red and Green from RAINBOW to COLORS.
12. Check to see that RAINBOW now contains only the files named Blue and Yellow.
13. Check to see that COLORS contains two files named Red and Green.
14. Delete the Yellow file in the RAINBOW directory.
15. Delete the RAINBOW directory.

16. Create a directory on the hard drive named your first name.

17. Copy the files on the disk in drive A to the directory on the hard drive with your name.

18. Format your data disk and then view its contents.

19. Make a system disk with your data disk. Use this system disk to restart the computer.

MFG-I3-LW2
Use File Management Systems
Attachment 3: **MASTER** Laboratory Worksheet No. 2

Using Windows 95 to Perform File Management Operations

*** A DATA DISK WILL BE NEEDED TO COMPLETE THESE EXERCISES. ***

1. Click START and choose Windows Explorer under Programs.
2. Maximize this window.
3. View the contents of your data disk in drive A and create a folder named SAMPLE on your data disk.
4. View the contents of the hard drive by selecting the root icon for drive C.
5. Expand the WINDOWS folder and view the files in the HELP subdirectory.
6. View the details of the files and arrange the files by size.
7. Select the four smallest files and copy them to the SAMPLE folder on drive A.
8. Check to see that these four files are still in the HELP folder on the hard drive. Now, view the contents of the SAMPLE folder on drive A to make sure the files were copied.
9. Rename each of the files under SAMPLE on drive A as File1, File2, File3, and File4.
10. Create another folder on drive A named EXERCISE.
11. Move the files File1 and File3 under SAMPLE to the folder named EXERCISE.
12. Check to see that SAMPLE now contains the files named File2 and File4.
13. Check to see that EXERCISE contains File1 and File3.
14. Delete File2 in SAMPLE.
15. Delete the folder SAMPLE.

16. Create a folder on the hard drive named PRACTICE.

17. Copy the files on the disk in drive A to the PRACTICE folder on the hard drive.

18. Format your data disk. Does it still contain your files?

19. Make your data disk a system disk. Explain the value of having a system disk.

MFG-I4-HO
Install and Use Software Packages
Attachment 1: MASTER Handout

Objectives:

Upon completion of this unit the student will be able to:

- a. Install a software package to a hard disk;
- b. Configure the system parameters upon installation;
- c. Create a word processing document;
- d. Create a spreadsheet; and,
- e. Open, edit, enhance, save, and print word processing and spreadsheet files.

Module Outline:

- I. Explain How to Install Software Packages Using Windows 3.1
  - A. Install from a CD-ROM
  - B. Install from diskettes
- II. Explain How to Install Software Packages Using Windows 95
  - A. Install from a CD-ROM
  - B. Install from diskettes
- III. Explain How to Configure System Parameters for a Software Package
  - A. Modification to AUTOEXEC.BAT and CONFIG.SYS
  - B. Modification of INI files (e.g. WIN.INI, SYSTEM.INI)
  - C. Plotter/printer driver configurations
  - D. Digitizer pad/mouse driver configurations
- IV. Use a Word Processor Software Package (e.g. WordPerfect, MS Word)
  - A. Typing a document
  - B. Using cursor movement keys
  - C. Editing a document with backspace and delete
  - D. Using the spelling checker
  - E. Saving a file
  - F. Printing a file
  - G. Closing a file
  - H. Opening a file
  - I. Changing the margins
  - J. Using bold, italics, and underline
  - K. Changing alignment
- V. Use a Spreadsheet Software Package (e.g. Lotus 123, MS Excel)
  - A. Entering values and labels
  - B. Editing the spreadsheet
  - C. Using formulas and functions
  - D. Changing column widths

E. **Changing number format**
F. **Changing alignment**
G. **Copying formulas and functions**
H. **Printing the spreadsheet**
I. **Saving the spreadsheet and chart**

Creating a Word Processing Document

I. Creating Documents

A. Key the following document in a word processing software package.

The Vernier Caliper
The basic parts of a vernier caliper are a main scale which is similar to a steel rule with a fixed jaw and a sliding jaw with a vernier scale. They are available in a wide range of lengths with different types of jaws and scale graduations.

B. Check your spelling.

C. Save the document on your data disk as CALIPERS and print.

D. Close the document.

E. Create another new document and enter the text below.

Micrometers
Micrometers are basic measuring instruments used by machinists in the processing and checking of parts. They are available in a wide range of sizes and types.

Outside micrometers are used to measure dimensions between parallel surfaces of parts and outside diameters of cylinders. Other types, such as depth micrometers, screw thread micrometers, disc and blade micrometers, and inside micrometers, also have wide application in the machine shop.

F. Boldface and italicize the title.

G. Change the top margin to 2.8 inches and check the spelling.

H. Save the document on your data disk under the name MICS and print.

I. Close the document.

II. Opening Documents and Editing

A. Open the document CALIPERS.

B. Insert Decimal-Inch in the title between "The" and "Vernier", so the title will read The Decimal-Inch Vernier Caliper. Also, boldface the title.

C. Insert the following text as the second sentence.

The vernier scale slides parallel to the main scale and provides a degree of precision to 0.001".

D. In the last sentence, change "They" to "Calipers".

E. Change the top margin to 2.7 inches and check your spelling.

F. Save under the same name and print.

G. Open the document MICS.

H. Make the two paragraphs one.

I. Save the document under the same name and print.

MFG-I4-LW2
Install and Use Software Packages
Attachment 3: **MASTER** Laboratory Worksheet No. 2

Creating a Spreadsheet

I. Create a Spreadsheet, Change Column Widths, and Alignment

A. Enter the following labels as shown below to create a spreadsheet. Change the column width as necessary.

Diametral Pitch	Number of Teeth	Pitch Diameter (inches)	Addendum (inches)	Dedendum (inches)

B. Center the labels in the cells.

C. In the Diametral Pitch column enter the following values: 4, 6, 8, and 3.

D. In the Number of Teeth column enter the following values: 45, 75, 44, and 54.

E. Save the spreadsheet to your data disk as BEVEL and print.

F. Open a new document and enter the following information below. Change the column widths as necessary.

Name	Rate	Hours	Gross Pay
Natalie Nicholson	6.80	40	
Dave Miller	8.60	40	
Karen Lark	8.60	38	
Taylor Smithsonian	5.50	20	

G. Center the values in the Hours column.

H. Set the number format in the Rate column to show two decimal places and the number format in the Hours column to show zero decimal places.

I. Save the spreadsheet to your data disk as PAYROLL and print.

II. Create and Copy Formulas/functions and Edit the Spreadsheet

A. Place BEVEL back on your desktop.

B. Enter the following formulas in the appropriate cell and copy to other cells where the formula is needed.

Pitch Diameter = Number of Teeth / Diametral Pitch
Dedendum = 1.157 / Diametral Pitch
Addendum = 1/ Diametral Pitch

C. Save under the same name and print.

D. Change the Diametral Pitch in the first cell from 4 to 5.

E. Change the Number of Teeth in the last cell from 54 to 50

F. Add a Diametral Pitch of 10 with the Number of Teeth given as 80.

G. Copy the formulas to the new row.

H. Save and print.

I. Place PAYROLL back on the desktop and enter the formula to compute the Gross Pay. (Gross Pay = Rate * Hours)

J. Format the Gross Pay as currency.

K. Add the Hours column.

L. Change Dave Miller's rate of pay to $9.00.

M. Save and print.

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

Duties	Tasks												
A Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
	B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MFG-J1-HO1
Discuss TQM in Manufacturing
Attachment 1: **MASTER** Handout No. 1

Objective(s):

Upon completion of this unit the student will be able to:

a. Understand the history of Total Quality Management process and its major historical contributors - Deming, Juran, and Crosby;
b. State the reason for intensive application of Total Quality Management principles, concepts and constitution parts in the industrial work places of America;
c. Identify the parts of the of the Total Quality Management formula (or the major element of TQM) - $TQM=(T^5 + SPC) X CI(CF) + E\&CS = P\&S$;
d. Understand the vital interplay of Training, Trust, Teamwork, Total Involvement and Transformation (T^5)to the successful implementation of TQM^2;
e. Understand the need for quantitative tools to base quality decisions on objective measurable information (Statistical Process Control - SPC);
f. Understand how Continuous Improvement (CI) with a Customer Focus (CF) is a vital philosophy with the power to multiply quality efforts of TQM^2;
g. State the importance of Employee and Customer Satisfaction (E&CS) to the successful implementation of TQM^2;
h. Understand how the meaning of quality is determined based on the prospective of supplier and customer;
i. Understand that the quality perceptions of the customer are of prime importance;
j. Identify external and internal customers and the importance of both to the successful implementation of TQM^2;
k. Know the essential importance of the Total Quality Management formula and its constitution parts to the Profitability and Survivability of a manufacturing enterprise; and,
l. Understand the importance of National TQM awards.

Module Outline:

I. Discuss the History of Total Quality Management Process and its Major Historical Contributors - Deming, Juran, and Crosby
II. Discuss the Reason for Intensive Application of Total Quality Management Principles, Concepts and Constitution Parts in the Industrial Work Places of America

III. **Discuss the Parts of the of the Total Quality Management Formula (Or the Major Element of TQM) - TQM=(T^5 + SPC) X CI(CF) + E&CS = P&S**
IV. **Discuss the Vital Interplay of Training, Trust, Teamwork, Total Involvement and Transformation (T^5) to the Successful Implementation of TQM^2**
V. **Discuss the Need for Quantitative Tools to Base Quality Decisions on Objective Measurable Information (Statistical Process Control - SPC)**
VI. **Discuss How Continuous Improvement (CI) With a Customer Focus (CF) Is a Vital Philosophy with the Power to Multiply Quality Efforts of TQM^2**
VII. **Discuss the Importance of Employee and Customer Satisfaction (E&CS) to the Successful Implementation of TQM^2**
VIII. **Discuss How the Meaning of Quality Is Determined Based on the Prospective of Supplier and Customer**
IX. **Discuss the Quality Perceptions of the Customer That Are of Prime Importance**
X. **Discuss External and Internal Customers and the Importance of Both to the Successful Implementation of TQM^2**
XI. **Discuss the Essential Importance of the Total Quality Management Formula and its Constitution Parts to the Profitability and Survivability of a Manufacturing Enterprise**
XII. **Discuss the Importance of National TQM Awards**

MFG-J1-HO2
Discuss TQM in Manufacturing
Attachment 2: **MASTER** Handout No. 2

Handouts/Overheads

1 handouts/overheads

TQM FORMULA

$$TQM=(T^5+SPC) \text{ X } CI(CF) + E\&CS=P\&S$$

T^5 = Training
Trust
Teamwork
Total Involvement
Team Formation
SPC = Statistical Process Control
CI = Continuous Improvement
CF = Customer Focus
E&CS = Employee &Customer Satisfaction
P&S = Profit & Survivability

2 handouts/overheads

Customer and Perception:

Customers perceive the quality of a service by comparing the actual service to what their expectations of service were before using or purchasing the service.

Service is judged to be unsatisfactory when expectations are not met.

Satisfactory when expectations are met and more than satisfactory when expectations are exceeded.

Successful organizations are able to diagnose the full set of customers' expectations and satisfy them completely, every time.

World class organizations have the ability of understanding implicit and even latent requirements of customers.

3 handouts/overheads

These latent requirements are features that customers want but do not know are available and hence are unable to articulate in discussion with suppliers.

Expectations and thus perceptions can be determined by answering 4 key questions:

1. What product/service characteristics do customer want?
2. What performance level is needed to satisfy their expectations?
3. What is the relative importance of each characteristic?
4. How satisfied are customers with performance at the current level?

Characteristics of Quality Service:

Customers expect to receive value in the products and services they purchase or use.

Value can be defined as the relationship between what customers get in exchange for what they give. This has usually been considered as the trade-off between price and quality, but more is involved.

CUSTOMER anyone to whom you (personally, your department, or the institution) provide service, product, or information. For many, your primary customer(s) will be other employees.

Performance Level Needed to Satisfy Expectations

3 Performance Levels:

Level 1 (Implicit) Base Expectations -
Minimum performance levels always assumed present

Level 2 (Explicit) Specifications and Requirements -
Options and trade-offs available for selection by customer

Level 3 (Latent) Delight -
Value Added characteristics and features that customers did not expect. Not just more; unanticipated.

What performance level is needed to satisfy expectations?

Service quality features are measured in subjective, qualitative terms based on observations and comparisons.

QUALITY:

A basic business strategy that provides goods and services that completely satisfy both internal and external customers by meeting their expectations.

This strategy utilizes the talents of all employees, to the benefit of the organization in particular and society in general, and provides a positive financial return to the shareholders.

Total Quality Management:
Arthur R. Tenner & Irving J. DeToro

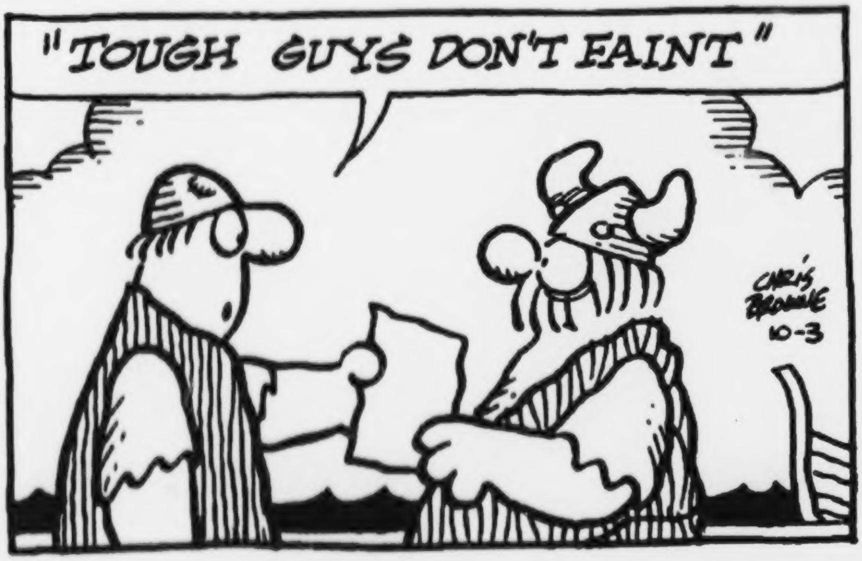
WHAT IS A TOTAL QUALITY MANAGEMENT SYSTEM?

Quality is not determined by the worker on the shop floor, nor is it determined by the service technician working at the customers's site.

Quality is determined by the senior managers of an organization, who by virtue of the positions they hold, are responsible to customers, employees, suppliers, and shareholders for the success of the business.

Total Quality Management:
Arthur R. Tenner & Irving J. DeToro

9 handouts/overheads


"TOUGH GUYS DON'T FAINT"
CHRIS BROWNE
10-3

SENIOR MANAGERS:

- Allocate resources
- Decide which markets the firm will enter
- Select and implement the management processes that will enable the firm to fulfill their mission and their vision

Formulating and devising the systems under which the workers perform their functions.

MOTIVATING FACTORS FOR TQM

---

1 Reality of the global market place

2 Competition in global market place means maximize savings by doing the job right the first time.

3 Speed of technology transfer makes for a level playing field and negates advantage.

4 Primary competitive advantages
  - People
  - Processes

5 TQM improves working environment which improves:
  - Morale
  - Employee retention

What is TQM?

> A philosophy of management

> A new way of thinking and conducting business

> A system that when implemented will bring about continuous improvement

> A structured system which will help you solve customer problems

> Using the collective knowledge and talents of all people in the organization

> Intensified by the use of statistical process controls

> Implemented now but will continue forever

CONTINUOUS IMPROVEMENT CONCEPT

Continuous improvement - is a philosophy and an attitude for analyzing capabilities and processes and improving them repeatedly to achieve one objective "customer satisfaction".

Customer satisfaction - result of meeting or exceeding customer expectations.

Value - relationship between quality and cost. Value is what the customer wants.

BASIC IDEA IN CONTINUOUS IMPROVEMENT

Empowering all people in a company to act on the basis of factual knowledge of the process in which they are involved will result in better products and services, delivered faster and at a greater profit.

15 handouts/overheads

CONTINUOUS IMPROVEMENT CONCEPT

Goal of customer satisfaction and value

Achieved by:

- Systematic analysis of what is being done, for whom, and why
- Application of process improvement methods

Focus of continuous improvement

. . . is on improving the work process (how things are done) by ourselves, our company and our suppliers.

CONTINUOUS IMPROVEMENT CONCEPT

Eliminate activities in the process:

- That add no value (what customer wants)
- Cause bottlenecks that block superior performance

Basic concept of continuous improvement:

Each person in a process is both a supplier and a customer. We gather the inputs we need for our work from our suppliers. Perform our work process producing output for our customers.

CONTINUOUS IMPROVEMENT CONCEPT

New culture at a company -
Culture that is more focused on satisfying requirements and expectations of both internal and external customers.

New culture characterized by improved methods of operation arising from:

- Participative management
- Teaming
- Process knowledge and improvement

Why:

- Increased competition
- Customer demand
- Needs of the work force

CUSTOMER ________

The next person (individual or group) in a process that receives your output and acts on it.

A customer may be:

- Internal
- External

Concept of **internal customers** is important because is has been shown that an organization cannot successfully meet the needs of its external customers if each output passed between employees within a company is deficient.

WHO IS MY CUSTOMER OR WHO ARE MY CUSTOMERS?

Answer 2 questions:

1. What is the output of my work?

   What is it I do?

2. Who receives the output of my work?

   For whom is it I do it for?

DETERMINE CUSTOMER EXPECTATIONS

Once customers are identified, their expectations can be determined by answering 4 key questions:

1. What product/service characteristics do customers want?
2. What performance level is needed to satisfy their expectations?
3. What is the relative importance of each characteristic?
4. How satisfied are customers with performance levels at the current level?

MAJOR ELEMENTS OF TQM

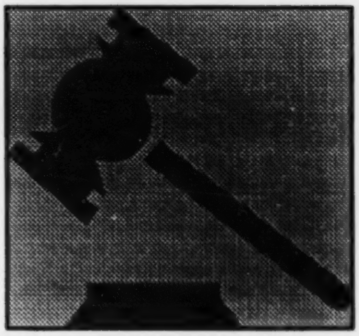
Total quality management . . .

- Depends on leadership from the highest levels of the organization
- Is focused on the requirements of the customer
- Requires cultural change involving:
    - Training
    - New processes
- Requires teamwork
- Involves continuous process improvement grounded on data based problem solving
- Requires long term commitment

CUSTOMER PERCEPTION

Customers tend to perceive the quality of a service by comparing actual service experienced to what their expectations and desire were before using or purchasing the service.

SERVICE IS JUDGED TO BE:



Unsatisfactory:
when expectations are not met.

Satisfactory:
when expectations are met.

Delight:
when expectations have been exceeded.

Successful Organizations
are able to diagnose the full set of customers' expectations and satisfy them completely,

World Class Organizations

have the ability of understanding implicit and even latent customer requirements.

Latent requirements are features that customers want but do not know are available and hence are unable to articulate in discussions.

Step 1 - Identify Customer

Who is my customer or who are my customers?

Answer 2 questions:

1. What is the output of my work?

   What is it I do?

2. Who receives the output of my work?

   For whom is it I do it for?

OUTPUTS the specific products or service that you produce, as part of your work process, and that you pass on to others, who, in turn, use them in their work process.

Output must be defined as specifically as possible.

Definitions like:

- Attitudes changed
- Work completed
- Too Vague
- Plans implemented

OUTPUT DEFINITIONS

Examples: ____________

Meeting...	planned? scheduled? recorded?
Reports...	researched? typed? distributed? filed?
Classes...	scheduled? developed? taught?

OUTPUTS ARE NOT:

- Things that you supervise or approve but things that are actually produce by others.
- Goals or outcomes for the organization.
- Steps in the work process.
- The overall function described by and individual's job title or responsibility.

CUSTOMER ________

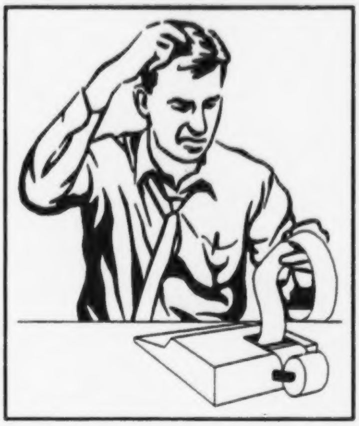
The next person (individual or group) in a process that receives your output and acts on it.

A customer may be:

- Internal
- External

Concept of internal customers is important because is has been shown that an organization cannot successfully meet the needs of its external customers if each output passed between employees within a company is deficient.

Step 2 - Determine Customer Expectations



Once customers are identified, their expectations can be determined by answering 4 key questions:

1. What product/service characteristics do customers want?

2. What performance level is needed to satisfy their expectations?

3. What is the relative importance of each characteristic?

4. How satisfied are customers with performance levels at the current level?

SERVICE CHARACTERISTICS:

Which are important to your customer's wants?

RELIABILITY: Consistency of performance and dependability.

- Performing the right service right the first time
- Honoring promises
- Accuracy

RESPONSIVENESS: Willingness or readiness of employees to provide service; timeliness.

COMPETENCE: Possession of the skills and knowledge required to perform the service.

ACCESS: Approachability and ease of access:

- Waiting time
- Hours of operation

COURTESY: Politeness, respect, consideration, and friendliness of contact personnel.

COMMUNICATIONS:

- Keeping customers informed in language they can understand
- Listening to customers
- Explaining the service itself
  - How much it will cost.
  - How problems will be handled.

CREDIBILITY:

- Trustworthiness
- Believability
- Honesty
- Institution's reputation
- Personal characteristics of personnel

SECURITY:

- Freedom from danger, risk or doubt
- Physical safety
- Confidentiality

UNDERSTANDING THE CUSTOMER:

- Making the effort to understand the customer's needs
- Learning the customer's specific requirements
- Providing individualized attention
- Recognizing the regular customer

TANGIBLES: Physical evidence of service:

- Physical facilities
- Appearance of personnel
- Tools or equipment used to provide service
- Other customers in service facility

APPLICATION OF THE 3 EXPECTATION LEVELS:

Recognizing the expectation level of any particular product/service characteristic offers three advantages:

First: It clarifies which characteristics should be discussed in detail with current or prospective customers.

Second: It helps to predict how the level of customer satisfaction might respond to a change in characteristics.

Third: It indicates possible future trends in expectations.

WHAT IS QUALITY?

(5 Definitions)

CONFORMANCE

If a box of cookies is to weigh 12 oz., conformance is boxes of cookies weighing a minimum of 12 oz., and a little more.

FITNESS FOR USE

Does the product perform a task as advertised?

This takes into account the design of the product not just its conformance to standards. Data on the fitness for use must be obtained "in the field."

RELIABILITY

Will the product perform its intended function in the specified environment for a prescribed length of time?

The time specified in a warranty indicates minimum length of time a product can be expected to perform satisfactorily.

Higher quality products generally come with longer warranty.

YIELD

What percent of products conform to specifications at each evaluation point?

Less waste means higher quality work. Higher in-plant product and process “yields” also tend to indicate better future product performances levels in the field.

CUSTOMER SATISFACTION

What value does the customer perceive?

Does the product meet customer expectations?

This is the **ULTIMATE** quality standard. Quality organizations provide products and services that go beyond customer satisfaction.

"Quality Is Job One"
(Ford)

"There is no substitute for quality.
Come home to quality."
(Anderson Windows)

"The Quality goes in before the name goes on!"
(Zenith)

"Quality starts with fundamentals"
(Raytheon)

"Our policy is quality"
(Paul Revere Life Insurance Co.)

Carnevale's, ***America and the New Economy,*** economic change has been brought about by the following factors:

- globalization of wealth/economic activity
- introduction of new technologies
- diversification of taste
- increasing value of human time
- commercialization of free labor
- increased participation of consumers in production and service delivery
- technical advances

40 handouts/overheads

What happened to trigger loss of market for American products?

American indifference was the cause:

- Indifference to changing demands in national and foreign markets for quality goods
- Indifference to the maintenance of a competitive manufacturing infrastructure that could produce quality goods
- Indifference to workforce to help in production of quality goods

Europeans and Japanese could not out produce the U.S. so they devised market strategies that would take advantage of America's indifference. One of the important strategies was the development of flexible organizations that reduced cost by focusing on the ***work process*** and ***quality***.

It takes more than productivity and low prices to win the competitive race.

It also takes quality.

Quality is primary among the new competitive standards of the world.

American productivity in computer chips has been good as or better than that of our competitors, yet by the late 1970s, we lost our market share because our chips were not as reliable as those produced in Japan.

NEW COMPETITIVE STANDARDS

#1 Quality

Measure of performance of the product or delivery of the service.

#2 Productivity

Ratio of output, the results of production to the corresponding input during a given period of time.

#3 Variety

The standardized offering of mass production have given way to an explosion of choices. Example: Consumers don't want just soap they want different colors, sizes, fragrances. Americans now choose among 572 different models of cars, vans, and trucks, compared with 408 in 1980.

#4 Customization

Products are individualized to meet wants and desires of customers to have a product that will meet a certain need or job. People do not want standardized or cookie cutter items.

#5 Convenience

3 types:
Build in - product is easy to use

Delivery - ease of obtaining the product Customer

Service - how the customer is treated by the staff or company.

#6 Timeliness

Develop products or services that are innovations before someone else does.

Not all American quality is poor. America still sets the world's quality standards in industries such as:

- Aerospace
- Aircraft
- Large Computers
- Appliances

Motorola (MB Award 1988):
Lowered defect rate from more than 5,000 defects per 1,000,000 chips to 500 defects and to 3.4 defects per 1,000,000 chips.

Xerox (MB Award 1989):
Installed a TQM program and overtook the Japanese lead in the photocopier market.

Harley-Davidson:
Reduced a manufacturing defect rate of 50% in 1972 to 1% of production using TQM.

GE, Whirlpool, Maytag, and other American appliance manufactures:
Initiated quality improvements before being challenged by overseas competitors.

Evolution of Quality

"If you build a better mousetrap, customers will beat a path to your door."

Frederick W. Taylor - introduced the concept of scientific management, which meant scientifically determining the "one best way" of performing a task or job. His theory was that by using the scientifically determined "best way" of performing a task productivity would be increased to the financial benefit of both the employer and employee.

Walter A. Shewhart - working for Bell Telephone Laboratories is now recognized as the “father” of quality control.

In 1924, he described what is now known as a control chart.

In 1931, he published the first known statistical quality textbook.

He introduced the importance of placing a process under statistical control in order to improve the design process.

Harold F. Dodge & H.G. Romig - used statistical theory to develop sampling inspection. Dodge-Romig Sampling Inspection Tables.

1934 - General Leslie Simon started using statistical quality control at the Picantinny Arsenal.

1940 - War Department requests the American Standards Association to standardize quality control techniques. Appointed were Harold F. Dodge (chairman), A.G. Ashcroft, W. Edward Deming, Leslie Simon and Ralph Wareham. Developed American War Standards chart.

1946 - W. Edward Deming went to Japan after war to study agricultural production for the War Department. Convinces Kenichi Koyangagi, one of the founders of the Union of Japanese Scientists and Engineers, of the potential of statistical quality control.

1950 - Deming starts teaching in Japan SQC to many of the top Japanese industrial leaders. U.S. management beginning to abandon the precepts learned in the wartime QC courses.

Joseph M. Juran - developed the principles of quality control originally used in Japan and now used in most of the world.

48 handouts/overheads

Philip B. Crosby - created the concept of "Zero Defects."

Kaoru Ishikawa - had a key roll in the development of quality in Japan. The cause-and-effect diagram is named in his honor. Leader in the development of quality circles.

Genichi Taguchi - developed the philosophy for a complete and integrated system to develop specifications, engineer the design to these specifications and manufacture the product to specifications.

49 handouts/overheads

QUALITY IS....

Meeting or exceeding your customer's expectations and requirements.

Requirements that are determined or modified through continuous communications between customers, workforce, and management.

Deming, 1986

What is TQM?

- A philosophy of management
- A new way of thinking and conducting business
- A system that when implemented will bring about continuous improvement
- A structured system which will help you solve customer problems
- Using the collective knowledge and talents of all people in the organization
- Intensified by the use of statistical process controls
- Implemented NOW but will continue forever

What is in it for me?

TQM Benefits

- Reduced customer complaints
  - Increased customer retention
  - Increased customer satisfaction

- Increased ability to attract new customers
  - Increased market share
  - Stay in business

- Increased workforce satisfaction
  - Reduced turnover
  - Provide jobs and more jobs

- Better services from the same dollars
  - Improved productivity
  - Reduction of waste
  - Reduction in rework
  - Reduction in inspection time

51 handouts/overheads

TQM Involving Employees

Training
Teaming
Communicating
Empowering
Recognizing

MFG-J2-HO
Demonstrate Quality Problem Solving Techniques
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Understand the need in today's fast paced business environment to improve manufacturing processes and efficiency through the diligent use of a problem solving model;
b. Identify the six steps of the six-step problem solving model;
c. Identify each of the sub-steps of the six-step problem solving model;
d. Apply the six-step problem solving model in individual and in team situations within the manufacturing environment;
e. Understand the "Circle of Influence" phenomenon and its impact on successful problem solving in the manufacturing environment; and,
f. Use problem solving tools, e.g., brainstorming, cause and effect diagram, paired choice matrix, and the criteria ranking form.

Module Outline:

I. Discuss the Need in Today's Fast Paced Business Environment to Improve Manufacturing Processes and Efficiency Through the Diligent Use of a Problem Solving Model
II. Discuss the Six Steps of the Six-Step Problem Solving Model
III. Discuss Each of the Sub-Steps of the Six-Step Problem Solving Model
IV. Discuss the Six-Step Problem Solving Model in Individual and in Team Situations Within the Manufacturing Environment
V. Discuss the "Circle of Influence" Phenomenon and its Impact on Successful Problem Solving in the Manufacturing Environment
VI. Discuss Problem Solving Tools, e.g., Brainstorming, Cause and Effect Diagram, Paired Choice Matrix, and the Criteria Ranking Form

MFG-J3-HO
Demonstrate Knowledge of SPC Concepts
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this unit the student will be able to:

a. Understand basic statistic for manufacturing process control;
b. Define variation and probability;
c. Identify the difference between "natural variation" and "unnatural variation";
d. Describe the difference between expected occurrence and actual occurrences of an event;
e. Identify a histogram;
f. Recognize and describe the normal distribution curve;
g. Understand the usefulness of the normal or bell curve to SPC;
h. Explain how the area under the normal curve is divided into standard deviations, or sigma (σ) units;
i. Define and calculate mean and range;
j. Apply a formula to estimate standard deviation;
k. Describe the relationship between the distributions of individuals and sample averages;
l. State the purpose of a control chart;
m. Identify the central line of a control chart;
n. Explain the difference between control limits and engineering specifications or tolerances;
o. Describe why the control chart has so much power;
p. Describe the purpose of a process capability study;
q. Define control chart variables and explain what X "bar" and R charts illustrate about a manufacturing process;
r. Explain the relationship between X "bar" (mean of sample) and R (range) of samples;
s. Define attributes and explain what "p" charts tell about a manufacturing process;
t. Interpret control charts by identifying the patter of points that shows the presence of a normal distribution; and,
u. Recognize the five signs that show a process may be out of control.

Module Outline:

I. Discuss Basic Statistic for Manufacturing Process Control
II. Discuss Variation and Probability

III. Discuss the Difference Between "Natural Variation" and "Unnatural Variation"
IV. Discuss the Difference Between Expected Occurrence and Actual Occurrences of an Event
V. Discuss a Histogram
VI. Discuss and Describe the Normal Distribution Curve
VII. Discuss the Usefulness of the Normal or Bell Curve to SPC
VIII. Discuss How the Area under the Normal Curve Is Divided into Standard Deviations, or Sigma (Σ) Units
IX. Discuss and Calculate Mean and Range
X. Discuss a Formula to Estimate Standard Deviation
XI. Discuss the Relationship Between the Distributions of Individuals and Sample Averages
XII. Discuss the Purpose of a Control Chart
XIII. Discuss the Central Line of a Control Chart
XIV. Discuss the Difference Between Control Limits and Engineering Specifications or Tolerances
XV. Discuss Why the Control Chart Has So Much Power
XVI. Discuss the Purpose of a Process Capability Study
XVII. Discuss Control Chart Variables and Explain What X "Bar" and R Charts Illustrate about a Manufacturing Process
XVIII. Discuss the Relationship Between X "Bar" (Mean of Sample) and R (Range) of Samples
XIX. Discuss Attributes and Explain What P Charts Tell about a Manufacturing Process
XX. Discuss Control Charts by Identifying the Patter of Points That Shows the Presence of a Normal Distribution
XXI. Discuss the Five Signs That Show a Process May Be out of Control

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

Duties	← Tasks →												
A Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
	B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

MFG-K1-HO
Recognize Electrical Components
Attachment 1: MASTER Handout

Objective(s):

Upon completion of this module the student will be able to:
1. Recognize the various components of electrical power systems;
2. Recognize and control hazards unique to electrical systems; and,
3. Use electrical tables to compute system demands and loads.

Module Outline:

I. Electrical Annotations and Symbols in Blueprints
II. Electrical Components
  A. Terminology
    1. Volt
    2. Ampere
    3. Ohm
    4. AC vs DC
    5. Watt
  B. Wire
    1. Sizes
      a. AWG and KCIL
      b. Relationship of size to ampacity
    2. Types of coverings
      a. THHN and its kin
      b. XHHW and its kin
      c. NMB vs UFB
      d. SJO and SJOW
      e. Other types
    3. Aluminum vs Copper
    4. Cupro-nickel internal wiring
    5. Co-axial cable
  C. Circuit breakers
    1. Sizes
    2. Voltage ratings
    3. Poles
    4. Three-phase
  D. Fuses
    1. Types
      a. Cartridge types
      b. Edison or large-base plug fuses
      c. Small-base plug fuses

            - d. Adaptors for fuse types
        - 2. Time delay vs. fast blowing
        - 3. Reading Edison and small-base fuses to determine overload or short circuit
    - E. Boxes
        - 1. Sizes
        - 2. Composition (PVC, Metal)
        - 3. Counting wires in a box
    - F. Tubing
        - 1. Sizes
        - 2. Composition (PVC, EMT, Rigid)
        - 3. BX and shielded cable
        - 4. Connectors and corners
            - a. Tube to tube
            - b. Mounting for tubes
            - c. Tube to box
            - d. Tees, elbows, and sweeps
    - G. Switches
        - 1. Poles and throws
        - 2. Two-way, three-way, and four-way
        - 3. A/B switches
    - H. Receptacles
        - 1. Small-faced configurations
        - 2. Large-faced configurations
        - 3. Tine patterns and ratings
    - I. Motor controls
        - 1. Relays
        - 2. Starting capacitors
        - 3. Surge considerations
        - 4. Three-phase controls
- III. Electrical Hazards
    - A. Protective clothing
    - B. Insulated tools
    - C. Amperes can kill!
    - D. Testing live wires
- IV. Using the NEC Tables
    - A. Determination of voltage drop
    - B. Maximum ampacity tables
    - C. Common horsepower tables
    - D. Other tables

MFG-K1-LW
Recognize Electrical Components
Attachment 2: **MASTER** Laboratory Worksheet

I. **The instructor should take the students on a tour of the facility. This tour should focus on the electrical power controls of the buildings.**

II. **Taking the circuits from the Self-Assessment Answer Key, Questions 9 and 10, the students will set up the mock-up breaker panel.**

III. **The students will calculate the total load of the mock-up panel and determine the appropriate size of the panel's main breaker.**

IV. **The instructor may demonstrate the differences in blown fuses, and distribute some of them amongst the students for identification. This section is optional.**

MFG-K2-HO
Use Electrical Test Equipment
Attachment 1: **MASTER** Handout

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

Objective(s):

Upon completion of this module the student will be able to:
- a. Properly use electrical test equipment;
- b. Measure ohms;
- c. Measure DC volts;
- d. Measure AC volts; and,
- e. Measure DC amps.

Reading Assignments:

The following chapters are assigned to read from *Electricity I*, Kubala, Delmar Publishing, Latest Edition:

Chapter	Title
6	Circuits

Module Outline:

- I. DC Voltage Measurement
- II. AC Voltage Measurement
- III. DC Current Measurement
- IV. Resistance Measurement

MFG-K2-LA
Use Electrical Test Equipment
Attachment 2: MASTER Laboratory Aid

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

MFG-K2-LW
Use Electrical Test Equipment
Attachment 3: MASTER Laboratory Worksheet

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1. Student will practice performing:
   a. DC voltage measurement;
   b. AC voltage measurement;
   c. DC current measurement; and,
   d. Resistance measurement.

2. Instructor will grade student's performance on:
   a. DC voltage measurement;
   b. AC voltage measurement;
   c. DC current measurement; and,
   d. Resistance measurement.

MFG-K3-HO
Troubleshoot Electrical Devices
Attachment 1: MASTER Handout

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

Objective(s):

Upon completion of this module the student will be able to troubleshoot the following devices:

a. Resistors;
b. Capacitors;
c. Inductors;
d. Motors; and,
e. Relays.

Reading Assignments:

The following chapters are assigned to read from *Basic Electronics*, Grob, McGraw-Hill Publishers, Latest Edition:

Chapters	**Title**
17	Capacitance
20	Inductance

Module Outline:

I. Resistors
II. Capacitors
III. Inductors
IV. Motors
V. Relays

MFG-K3-LA
Troubleshoot Electrical Devices
Attachment 2: MASTER Laboratory Aid

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

MFG-K3-LW
Troubleshoot Electrical Devices
Attachment 3: MASTER Laboratory Worksheet

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1. Student will practice troubleshooting:
    - a. Resistors;
    - b. Capacitors;
    - c. Inductors;
    - d. Motors; and,
    - e. Relays.

2. Instructor will grade students performance on troubleshooting:
    - a. Resistors;
    - b. Capacitors;
    - c. Inductors;
    - d. Motors; and,
    - e. Relays.

MANUFACTURING TECHNICIAN .... recommends and implements solutions for specific manufacturing applications.

	Duties	← Tasks →												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Use protective equipment	A-3 Follow safe operating procedures for hand and machine tools	A-4 Maintain a clean and safe work environment	A-5 Lift safely	A-6 Control fire hazards	A-7 MSDS/ Control chemical hazards						
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Convert fractions/ decimals	B-3 Convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Use practical geometry	B-6 Understand basic trigonometry	B-7 Calculate speeds and feeds for machining	B-8 Use coordinate systems	B-9 Perform calculations for sine bar and sine plate	B-10 Calculate for direct, simple, and angular indexing	B-11 Perform calculations necessary for turning tapers	B-12 Calculate depth of cut for round surfaces	B-13 Use all functions on a scientific calculator
		B-14 Solve static systems for resultant force	B-15 Determine strength of materials for various applications											
C	Interpret Engineering Drawings and Control Documents	C-1 Identify basic layout of drawings	C-2 Identify basic types of drawings	C-3 Review blueprint notes and dimensions	C-4 List the purpose of each type of drawing	C-5 Verify drawing elements	C-6 Practice Geometric Dimensioning and Tolerancing (GD&T)	C-7 Analyze bill of materials (BOM)	C-8 Describe the relationship of engineering drawings to planning	C-9 Understand and use quality systems	C-10 Verify standard requirements			
D	Recognize Different Manufacturing Materials and Processes	D-1 Identify materials with desired properties	D-2 Identify materials and processes to produce a part	D-3 Describe the heat treating process	D-4 Test metal samples for hardness	D-5 Understand welding operations	D-6 Evaluate plastics, composites and other manufacturing processes							
E	Measure/Inspect	E-1 Understand metrology terms	E-2 Select measurement tools	E-3 Measure with hand held instruments	E-4 Eliminate measurement variables	E-5 Measure/ inspect using surface plate and accessories	E-6 Inspect using stationary equipment							
F	Perform Conventional Machining	F-1 Prepare and plan for machining operations	F-2 Use hand tools	F-3 Operate power saws	F-4 Operate drill presses	F-5 Operate vertical milling machines	F-6 Operate horizontal milling machines	F-7 Operate metal cutting lathes	F-8 Operate grinding/ abrasive machines					
G	Perform Advanced Machining	G-1 Prepare and plan for CNC machining operations	G-2 Select and use CNC tooling systems	G-3 Program CNC machines	G-4 Operate CNC machining centers (mills)	G-5 Operate CNC turning centers (lathes)	G-6 Program CNC machines using a CAM system	G-7 Download programs via network						
H	Program Using CAM System	H-1 Understand CAD/ CAM programs	H-2 Manipulate CAD functions	H-3 Process simple toolpath data	H-4 Create advanced surface models	H-5 Process complex toolpath functions								
I	Use Computers	I-1 Use computer operating systems	I-2 Understand computer terminology	I-3 Use file management systems	I-4 Install and use software packages									
J	Participate in Total Quality and SPC Activities	J-1 Discuss TQM in manufacturing	J-2 Demonstrate quality problem solving techniques	J-3 Demonstrate knowledge of SPC concepts										
K	Maintain Electrical Devices	K-1 Recognize electrical components	K-2 Use electrical test equipment	K-3 Troubleshoot electrical devices										
L	Maintain Hydraulic/ Pneumatic Devices	L-1 Troubleshoot, maintain, and repair hydraulic systems	L-2 Troubleshoot, maintain, and repair pneumatic systems											

DutyL

MFG-L1-HO
Troubleshoot, Maintain, and Repair Hydraulic Systems
Attachment 1: MASTER Handout

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

Objectives:

Upon completion of this module the student will be able to:
a. Troubleshoot hydraulic system;
b. Maintain hydraulic system; and
c. Repair hydraulic system.

Reading Assignments:

The following chapters are assigned to read from *Fluid Power 1,* by Parker Publishers, Latest Edition:

Chapter	Title
3	Energy Transmission Using a Hydraulic System
4	Control of Hydraulic Energy
7	Hydraulic Pumps
8	Check Valves, Cylinders and Motors
10	Directional Control Valves
12	Pilot Operated Pressure Control Valves

Module Outline:

I. Hydraulic Theory
II. Storage Devices
III. Pumps-Prime Movers
IV. Actuators
V. Control Devices
VI. Accumulators

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

MFG-L1-LW
Troubleshoot, Maintain, and Repair Hydraulic Systems
Attachment 3: MASTER Laboratory Worksheet

Worksheet:

1. Student will practice:
   a. Troubleshooting hydraulic system;
   b. Maintaining hydraulic system; and,
   c. Repairing hydraulic system.

2. Instructor will grade student's performance.

MFG-L2-HO
Troubleshoot, Maintain, and Repair Pneumatic Systems
Attachment 1: MASTER Handout

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

Objectives:

Upon completion of this module the student will be able to:

a. Maintain pneumatic system;
b. Troubleshoot pneumatic system; and,
c. Repair pneumatic system.

Reading Assignments:

The following chapters are assigned to read from *Fluid Power 1*, by Parker Publisher, Latest Edition:

Chapters	Title
5	Energy Transmission Using A Pneumatic System
11	Simple Pressure Control Valves

Module Outline:

I. Pneumatic Theory
II. Compressor
III. Regulators
IV. Valves
V. Actuators
VI. Safety
VII. Prevention Maintenance
VIII. Troubleshooting Pneumatic Devices
IX. Repair Pneumatic Devices

Standards of performance:

Student shall demonstrate safe work habits in the shop by:
Using OSHA required safety equipment for the shop;
Safety glasses;
Hearing protection;
Face shields;
Gloves;
Not wearing rings, watches, jewelry, or loose clothing while operating equipment; and,
Not participating in horse play or practical joking.

MFG-L2-LW
Troubleshoot, Maintain, and Repair Pneumatic Systems
Attachment 3: MASTER Laboratory Worksheet

Worksheet:

1. Draw a circuit utilizing a single acting cylinder, gravity return, as the load. Use a directional control valve. Make the cylinder extend. Have the instructor approve the diagram. Construct the circuit. Have the instructor approve the circuit. Run the circuit.

2. Same as Problem #1, except use double acting cylinder.

3. Practice PM on an existing pneumatic system.. Instructor will go over typical PM procedures.

4. Same as Problem #1, except use meter-out circuit.

5. Same as Problem #1, except use a quick exhaust circuit.